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JOURNAL OF PALEONTOLOGY

JOSEPH A. CUSHMAN, Editor

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Volume 4 Number 1

JOURNAL OF PALEONTOLOGY

MARCH 1930

OPHIUROID REMAINS OF PENNSYLVANIAN AGE

By J. MARVIN WELLER[1]
Urbana, Illinois

ABSTRACT

Vertebral ossicles of ophiuroid starfish have been collected from Pennsylvanian strata at two localities. Three distinct types are represented. The very perfect preservation makes it possible to observe the details of articulation and musculature which are so rarely to be made out in these interesting and unusual fossils.

Star fish are among the rarest of Paleozoic fossils and only 74 species have been described from the Paleozoic strata of North America[2]. About 20 of these are of Carboniferous age and most of them have been obtained from the Mississippian formations of the upper Mississippi Valley. Up to this time no star fish have been reported from the Pennsylvanian or Permian strata of this continent and the recent discovery, therefore, of remains of these animals in Pennsylvanian beds in Illinois and Indiana is worthy of comment.

The study of Paleozoic star fish is unusually difficult as many specimens are simply moulds in impure limestone or fine sandstone. In cases where the plates have been preserved, they are commonly highly calcified and more or less completely collapsed, so that only the external relations of the plates can be determined. Because of lack of data on internal skeletal structure, therefore, the classification which

[1] Published by permission of the Chief, Illinois State Geological Survey.
[2] Schuchert, Charles, Revision of the Paleozoic Stelleroidea, etc., U. S. Nat. Mus., Bull. 88, 1915.

has gradually grown up is based largely upon shape and the external form and arrangement of the surface plates and spines and is consequently more or less artificial.

The beautiful preservation of pyritized star fish in the Lower Devonian roofing slates of Bundenbach in Germany, has allowed Schöndorf to make observations upon various skeletal structures[3]. Sollas and Sollas have worked out the internal structures of a Silurian ophiuroid by the study of a large number of serial sections ground through a calcified specimen[4]. Spencer achieved similar results by making gutta-percha impressions of specimens whose ossicles were slightly dislocated[5]. No comparable observations have been made by American workers.

The material described in this paper consists of isolated, individual, vertebral ossicles. Although these are small in size, the largest being less than 2 millimeters in length, they are beautifully preserved and may be studied directly. The calcitic specimens from Jersey County, Illinois, were washed from a shale that occurs just below the Piasa limestone in the NE. ¼ sec. 25, T. 8 N., R. 10 W. The silicified specimens from Warren County, Indiana, were obtained by dissolving in hydrochloric acid, fragments of a dense dark gray limestone which occurs in the lower part of the Pennsylvanian section in the NW. ¼ sec. 35, T. 21 N., R. 9 W. No plates of star fish other than the vertebral ossicles have been recognized from either of the localities.

It is, of course, impossible to reach a conclusion regarding the systematic position of these Pennsylvanian star fish, merely from study of the vertebral ossicles. These plates are, however, characteristic of Schöndorf's subclass Auluroidea[6] and were it not for Spencer's more recent work in which he shows that such forms do not constitute a distinct group but are true Ophiuroids[7], they might be so classed without hesitation. In view of Spencer's conclusion, however, the ossicles described in this paper are referred simply to the Ophiuroidea.

With the information at hand these Pennsylvanian forms can not be placed in any previously proposed family. If they were more completely known it might be possible to find a place for them but the chances are that it would be necessary to erect a new family for their reception. Considering their generic position, however, it is fairly certain that they are distinct from any previously described forms, as

[3] Schöndorf, F., Palaozoische Seesterne Deutschlands II, Palaeontographica, vol. 57, pp. 1ff., 1910.
[4] Sollas, I. B. J., and Sollas, W. J., Lapworthuria: a typical brittle star of the Silurian Age, etc., Roy. Soc. London, Phil. Tr., vol. 202B, p. 213, 1912.
[5] Spencer, W. K., Monograph of the British Paleozoic Asterozoa, p. 246, Palaeontographical Society, 1922 (1925).
[6] Schuchert, Op. cit., p. 213.
[7] Spencer, Op. cit., p. 242, 251.

the ossicles are different from those of any known star fish. Finally these ossicles represent species which have certainly never before been described.

Several new names for these Pennsylvanian ossicles might be proposed but such names could have little significance until relatively complete specimens are available for study.

The specimens described are all in the collection of the Illinois State Geological Survey.

DESCRIPTION OF SPECIES

Class STELLEROIDEA

Subclass OPHIUROIDEA

Order Unknown

New Family?

New Genus or Genera

OPHIUROIDEA sp. A
Plate 1, figs. 1 *a*-2 *b*

Description.—The vertebral ossicles are small, the largest observed specimen being less than 2 millimeters in length. They are formed of two opposite ambulacralia firmly joined together. The position of the suture separating the two parts is not conspicuous but may be observed on some parts of certain specimens although none has been seen that shows a continuous suture, and other specimens have no indication of a suture. In the majority of specimens it may be best observed extending down the center of the oral and apical surfaces.

These ossicles are notably wedge shaped and may have a width below nearly twice as great as that above. The wedge shape is most pronounced when the ossicle is viewed from the adoral surface. The proportions of the various ossicles vary considerably. All of them are comparatively long and in most cases the length exceeds either the height or the width. The height may approximately equal the width or it may exceed it considerably and the proportion of these dimensions is probably dependent upon the relative positions of the various ossicles in the arm.

The vertebral ossicles are all pierced lengthwise by the comparatively large circular canal of the ambulacral water-vascular system.

The canal is located in the lower part of the ossicle approximately in its widest part.

The successive vertebral ossicles articulated by means of a highly specialized series of knobs and sockets similar to those of many modern Ophiuroidea. These are arranged in a vertical and a horizontal system. The vertical system is composed of a dorsal knob upon the adoral surface and a ventral knob upon the aboral surface and their corresponding sockets. The dorsal knob is symmetrically subhemispherical in form. It is connected below with a broad rather flat elevated ridge which extends to the opening of the water-vascular canal. This opening is at the bottom of a shallow funnel-like depression which serves as the socket for the ventral knob.

The ventral knob consists of a rather thin rim which extends outward and surrounds the opening of the water-vascular canal on the aboral surface. This rim is most prominent below, is lower on the sides and above merges into an elevated Y-shaped process. The depression included between the arms of this Y forms the socket for the dorsal knob.

The horizontal hinge is formed by two knobs upon the adoral surface and their corresponding sockets in the aboral surface of the next succeeding ossicle. The knobs are upon either side of and slightly below the opening of the water-vascular canal. They are somewhat angular in form and their upper and inner surfaces rise steeply from the edge of the funnel-like ventral socket. The sockets of the horizontal hinge occur upon either side of and slightly below the ventral knob on the aboral surface. They occupy the upper and inner portions of the depressions which also contained the paired ventral muscles.

The vertebral ossicles were joined by two sets of paired muscles. The depressions in which the ventral muscles were attached are the deeper and more conspicuous and seem to indicate that these muscles were the more powerful. The depressions of the ventral muscles on the adoral surface are situated at the lower outer corners of the ossicle and are deeply excavated. They are almost equally prominent on the aboral surface where they are located below and on either side of the ventral knob and below two elevated flattened areas which occupy the outer portions of the aboral surface.

The dorsal paired muscle fields are less well defined. Upon the adoral surface they lie below the dorsal knob and upon either side of the ridge which extends from the dorsal knob to the ventral socket. Upon the aboral surface these muscle fields are roughly triangular in

form. They are bounded upon the inside by the Y-shaped process which forms the dorsal socket and upon the outside and below by the elevated flattened areas mentioned above.

A depressed area which has the appearance of a muscle field lies upon the adoral surface above the dorsal knob. Above the Y-shaped dorsal socket on the aboral surface there is a larger depression continuous with this socket, which might conceivably also be a muscle field. If a fifth muscle or a third pair of muscles were present in this position, these ossicles differed radically from those of any other known Ophiuroid, either fossil or recent, all of which possessed only two sets of paired muscles. It seems probable therefore that the appearance of the depressions is deceptive and that they served some unknown purpose.

The sides of the vertebral ossicles are irregularly concave. The comparatively gentle inward slope from the apical, aboral and oral edges is interrupted by a more or less sharp outward deflection to the edge of the adoral surface. Judging by analogy with modern Ophiuroidia, the adambulacral plates were supported upon this deflection which corresponds to the wing of the vertebral ossicles of modern representatives of this group. Probably the adambulacrals were movable, for there are no indications of their firm attachment upon the ossicles.

The cups of the tube feet are conspicuous features of the vertebral ossicles and are both larger and deeper than in many modern Ophiuroidea. They are located on the lower outer edge of the ossicles distally of the middle. The openings of the branch water-vascular canals are tiny pores in the deepest part of the cups and lead in toward the center of the ossicle.

The central portion of the lower or oral surface of the vertebral ossicle bears a broad shallow groove which lodged the radial nerve cord and pseudohaemal canal. The outer proximal corners of the oral surface are occupied by broad elevated areas having shallow central depressions. These are probably the fields of muscles which served to move the adambulacrals, and their presence directly upon the oral surface may indicate that the side plates could be drawn down to completely cover the ventral surface of the rays. If this interpretation is correct it is probable that no ventral shields were present.

The apical surface is comparatively narrow and is completely occupied by a concave groove which contained the radial branch of the coelom. The deep hollow in the central portion of this notch indicates

that enlargements of this vessel occurred in each segment of the arms.

Remarks.—Only three species of auluroid Ophiuroidea have been described from Carboniferous strata. These are *Trematasterdifficilis* and *Cholaster peculiaris* Worthen and Miller from Chester strata in Illinois and *Aganaster gregarius* (Meek and Worthen) from the Warsaw limestone of Indiana. No other Carboniferous Ophiuroidea have previously been known from North America. The other continents have yielded five species but these are non-auluroid. All of these are of Lower Carboniferous (Mississippian) age and no Ophiuroidea of Upper Carboniferous (Pennsylvanian) age have ever been described from any part of the world.

The vertebral ossicles described in this paper are clearly auluroid, as shown by the wholly enclosed water-vascular canal. Comparison therefore is necessary only with the three American species noted above. Of these *Aganaster gregarius* is the best known but no observations of its vertebral ossicles have been made as the rays are so completely enclosed by covering plates that they are entirely hidden from view. The adambulacrals are large and practically cover the arm on all sides. Dorsal and ventral shields, if present at all, are very small. Spencer is of the opinion that the adambulacrals were fixed to the vertebral ossicles and were not capable of rotation[8]. Our Pennsylvanian ossicles must be quite different from those of *Aganaster*. The sloping surfaces upon which the adambulacrals rested and the muscle fields upon the oral surface indicate that the side plates were capable of being moved downward to cover the ventral surface. The form of the apical portion of the vertebral ossicles is such that it appears impossible for the adambulacrals to have met above as in *Aganaster*. It is probable that the adambulacrals of the Pennsylvanian form were comparatively short, and the conclusion that they could be drawn downward to cover the ventral surface suggests that probably there were no ventral shields. Whether the apical surface was protected by dorsal shields or a skin bearing calcareous granules cannot be determined.

Cholaster peculiaris is known from a single specimen showing only the apical surface. There is nothing in the original description or the figures to enable us to make any comparison.

Trematasterdifficilis is known from the actinal side but the description and illustrations offer little for comparison. It is possible that the Pennsylvanian form is related to this species but no definite statement can be made. It appears that, although ventral shields are absent

[8] Spencer, Op. cit., p. 284.

from *T. difficilis,* the adambulacrals could not be rotated over the ventral surface as probably was possible in the Pennsylvanian form. The genus *Trematraster* has been referred to Gregory's family Ophiurinidae and according to the original diagnosis the ambulacral ossicles should be only slightly united, which is certainly not the case with this Pennsylvanian form whose opposite ambulacrals are firmly fused into a single piece.

The Pennsylvanian vertebral ossicles present a combination of primitive and advanced characters. They are primitive in that the cups for the tube feet are large, the adambulacrals were movable and ventral shields were probably absent. They are advanced in the firm union of the opposite ambulacrals into vertebral ossicles and in the strong and well developed articulating knobs and sockets which in many ways are closely similar to those of modern forms.

Occurrence.—Silicified specimens were collected from a dark limestone near the base of the Pennsylvanian section in the NW. ¼ sec. 35, T. 21 N., R. 9 W., Warren County, Indiana.

OPHIUROIDEA, sp. A, var.
Plate 1, figs. 3 *a*, *b*

Remarks.—These specimens are closely similar to those described above. The general form, systems of articulation and musculature follow the same plan; the differences are of a relatively minor nature. It is not known whether such differences are of specific importance or whether they may not be variations which might occur within the same species or individual.

This variety differs from species A in the less prominent and more closely set articular knobs of the adoral surface, in the less prominent ventral knob of the aboral surface (this may be due to imperfect preservation), in the direction of the cups of the tube feet outward toward the side rather than downward, in the higher position of the muscles which moved the adambulacrals, the fields of which are clearly visible from the side, in the greater expansion of the lateral borders of the aboral surface, in the less conspicuous development of wings adjacent to the adoral surface upon which the adambulacrals moved, and in the more sharply defined dorsal groove of the coelom which is not noticeably deepened in the center.

Occurrence.—These specimens were washed from shale which occurs just beneath the Piasa limestone in the NE. ¼ sec. 25, T. 8 N., R. 10 W., Jersey County, Illinois.

OPHIUROIDEA, sp. B
Plate 1, figs. 4 *a-e*

Description.—The vertebral ossicle is small, subcylindrical and elongated. The length of the only specimen which has been found is about 1 millimeter. It is formed of two opposite ambulacrals solidly fused together. The suture separating the two halves is not conspicuous and is shown clearly only upon the oral surface.

The ossicle is subcircular to suboval in cross-section and is pierced near its center by a comparatively large circular canal which was occupied by the water-vascular branch that served the ray.

The vertebral ossicles articulated by means of four knobs and sockets, two forming a vertical hinge and the other two a horizontal one. The ventral knob (located almost in the middle of the aboral surface) is the most conspicuous articular structure. It is formed by a thin lip which extends outward and surrounds the aboral opening of the water-vascular canal. This lip attains its greatest projection below but is cleft by an obtuse notch along its median line. Above the ventral knob is a V-shaped depressed area the lower portion of which served as the socket for the dorsal knob.

Upon the adoral surface the opening of the water-vascular canal lies at the bottom of a funnel-like depression which is the socket of the ventral knob. Upon the upper edge of this socket is situated the subhemispherical, small, and rather inconspicuous dorsal knob.

The horizontal hinge is formed by two irregular knobs situated upon either side of and slightly below the opening of the water-vascular canal of the adoral surface. They are slight projections of the lower edges of the dorsal paired muscle fields and were received in two sockets which lie upon either side of the ventral knob of the aboral

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EXPLANATION OF PLATE 1

All figures enlarged 15 diameters

FIGS. 1 *a*–2 *b*.—*Ophiuroidea*, sp. A. 1 *a*, Side view of the largest specimen; 1 *b*, apical view; 1 *c*, oral view; 1 *d*, aboral view; 1 *e*, adoral view. 2 *a*, Aboral view of a smaller, differently proportioned specimen; 2 *b*, adoral view.

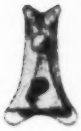
3 *a–b*.—*Ophiuroidea*, sp. A, var. *a*, Side view; *b*, apical view.

4 *a–e*.—*Ophiuroidea*, sp. B. *a*, Side view; *b*, apical view; *c*, oral view; *d*, aboral view; *e*, adoral view.

5 *a–e*.—*Ophiuroidea*, sp. C. *a*, Side view; *b*, apical view; *c*, oral view; *d*, aboral view; *e*, adoral view.

2a

1b

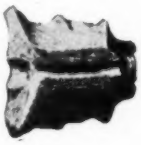


2b

1d

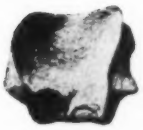
1a

1e



3b

1c



3a

4b

4d

4c

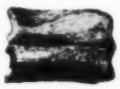
5b

4a

5a

5d

5e



4c

5c

surface and occupy the upper inner corners of the ventral paired muscle fields.

Similarly to other Ophiuroidea, this vertebral ossicle was joined to its neighbors by two sets of paired muscles. The fields of attachment of these muscles are somewhat unequally developed. Upon the adoral surface the dorsal muscle fields are well-defined elliptical depressions which lie upon surfaces sloping downward and outward along the upper edges of the ossicle. Upon the aboral surface however these muscles were attached along two rather ill-defined furrows which separate the V-shaped depression of the dorsal socket, and two raised flattened areas which occupy the lateral portions of the aboral surface. In contrast, the ventral muscle fields of the adoral surface are less conspicuous. They are situated upon either side of the ventral socket and below the knobs of the horizontal hinge. These muscles were attached to the aboral surface in somewhat deeper and better defined depressions in corresponding positions.

Above the dorsal knob is a shallow open notch bounded laterally by upraised edges which, like the ossicles described as species A, has the appearance of a muscle field. On the aboral surface, the socket of the dorsal knob is continued by a depressed V-shaped area which is also quite similar on the ossicles described above. Although these structures suggest that muscles were attached here, the fact that such muscles are unknown in other Ophiuroids makes it appear probable that the function of these parts was of another nature.

The sides of the vertebral ossicle are more or less regularly rounded, the ends are not conspicuously expanded, there is no wing to which the adambulacrals could have been attached, nor are there any indications of the attachment of muscles for the movement of the side plates.

The cups of the tube feet are relatively large. They are situated aborally and open both outward and downward. The pores connecting with the water-vascular canal are in the deepest part of the cups and lead directly toward the center of the ossicle.

The apical surface bears a shallow rounded groove of uniform proportions which held the radial projection of the coelom.

The oral surface also bears a notch or groove which contained the radial nerve trunk and the pseudohaemal canal. Adorally it is shallow and insignificant but aborally it widens and deepens into a hollow which occupies the ventral surface between the edges of the cups of the tube feet.

Remarks.—This vertebral ossicle, although differing greatly in appearance from the ossicles described as species A, still possesses struc-

tures which are essentially similar. Thus the systems of articulation and musculature, although differing in detail, are the same in essential particulars. The chief difference, aside from that of shape, concerns the structures which are related to the adambulacrals. These are well developed in species A but are absent in species B.

The vertebral ossicles of an Ophiuroid's arm are arranged in a tapering series. As the tip of the arm is approached the ossicles decrease in size and become longer in proportion to width and finally terminate in tiny calcareous rods. It is possible that the ossicle described above came from the same form as the ones described as species A. However, this does not appear probable as the specimens shown in figures 1 *a-e* and 2 *a, b* seem to indicate the direction of the variation which actually occurs. One could visualize ossicles intermediate between figures 1 and 4 but if figure 2 were to be inserted in this series the situation becomes more complicated, as figure 2 is in no respect intermediate between 1 and 4. It seems advisable therefore to regard the specimen under consideration as representative of a different species.

Occurrence.—A silicified specimen was obtained from dark limestone near the base of the Pennsylvanian section in the NW. ¼ sec. 35, T. 21 N., R. 9 W., Warren County, Indiana.

OPHIUROIDEA, sp. C
Plate 1, figs. 5 *a-e*

Description.—The only vertebral ossicle of this type which has been observed is very small, being about .73 millimeter long. It is composed of two opposite ambulacral plates firmly united but the suture which separates them is apparent nearly all the way around. This ossicle is pierced longitudinally by the comparatively large circular opening of the radial water-vascular canal.

The articular processes are poorly developed in comparison with the vertebral ossicles described as species A and B. The ventral knob on the adoral surface is fairly strong and is formed by a thin outward projecting rim which surrounds the opening of the water-vascular canal. The rim is strongest and thickest above, is thinner, and recedes below. This knob was received in a very shallow funnel-like socket of the adoral surface of the next ossicle which sloped gently into the opening of the water-vascular canal.

There is no dorsal knob upon the adoral surface of this vertebral ossicle nor is there any socket for the reception of such a structure on the aboral surface in a position comparable to that in species A or B.

There is a slight depression just above the ventral knob but this lies between rather than above the dorsal muscle fields. Either a dorsal knob was present (but destroyed on this specimen) in a position relatively lower than on either of the other two species or else (and this seems more likely in view of the very perfect preservation) the dorsal knob and its corresponding socket are unrepresented.

The structure of the horizontal hinge is also different from that of the other two species. In this specimen two projections are developed upon both the adoral and aboral surfaces. Those which most closely correspond to the horizontal knobs of the other species are present upon the aboral rather than the adoral surface. The projections rise upon either side of the ventral knob from the lower extremities of the raised areas which bear the fields of the dorsal paired muscles. Their corresponding sockets occur in the lower part of the depressed areas of the dorsal muscle fields of the adoral surface. The two knobs of the adoral surface are situated below the fields of the dorsal muscles and outside of the ventral paired muscle fields, and their sockets are located on the aboral surface in corresponding positions. Thus the knobs of the opposing surfaces were adjacent and moved upon each other in articulation.

This vertebral ossicle was joined to its neighbors by two sets of paired muscles which were attached in large and deeply excavated muscle fields. The dorsal muscles appear to have been the larger and stronger. They were attached to the adoral surface in broad and deep excavations which slope outward and slightly backward. Upon the aboral surface they occupied ellipsoidal depressions in two broad flattened areas which slope gently downward adjacent to the lateral edges of the ossicle. The ventral muscles were attached to the adoral surface in two depressed, ellipsoidal muscle fields below and upon either side of the opening of the water-vascular canal and to the aboral surface in two depressed areas in similar positions.

The cups of the tube feet are large and deep and are directed both outward and downward. The pores connecting with the main water-vascular canal are in the deepest part of the cups near the center of the ossicle.

The sides of the vertebral ossicle above the cups of the tube feet slope inward gently from the slightly expanded ends but no part of have moved these side plates.
the surface appears to have been specialized for the attachment of the adambulacrals nor are there any indications of muscles which may

Both the oral and apical surfaces of the ossicle are notched for the

reception of the coelom, and nerve trunk and pseudohaemal canal respectively. Neither of these notches is uniformly developed and each possesses a wider and deeper central portion.

Remarks.—This vertebral ossicle is very different from either of the other two types described. These differences include form, proportions, and articular and muscular systems. This ossicle might be considered as another of a gradational series which also includes the forms described as species A and B, but the entirely different systems of articulation make it difficult to visualize the necessary intermediate forms and this possibility seems very remote.

Occurrence.—A silicified specimen was collected in Warren County, Indiana, from a limestone near the Pennsylvanian section in the NW. ¼ sec. 35, T. 21 N., R. 9 W.

A NEW SPECIES OF EUPHEMUS

By J. MARVIN WELLER[1]
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ABSTRACT

The *Euphemus* described below is characterized by its ponderous shell and a thick callus on the inner lip. The coloration of some specimens is preserved. A polished section through one specimen shows the structure of the shell which is composed of six layers.

The Carboniferous fossils of Illinois have attracted the attention of paleontologists for nearly a century and hundreds of species have been described. Undoubtedly there still remain many forms that are new to science but most of these are probably comparatively small species which have escaped the notice of previous workers, or else they are forms that, due to the rather elastic specific limits employed by many of the early paleontologists, have not been differentiated from established species which they resemble. Considerable interest, therefore, attaches to the discovery in Pennsylvanian strata of western Illinois of a large species of gastropod which is conspicuously different from any form described up to this time. The perfect preservation of the specimens in our collection is also worthy of note. Inclosed in limestone, the shells have been protected from crushing and distortion and yet they may be worked out with comparative facility. But furthermore, the color patterns of some of these shells have been beautifully preserved and they stand out in all their details as plainly as somewhat similar patterns do on modern shells.

[1] Published by permission of the Chief, Illinois State Geological Survey.

Class GASTROPODA

Order ASPIDOBRANCHIA

Family BELLEROPHONTIDAE

Genus EUPHEMUS M'Coy

EUPHEMUS CALLOSUS Weller, n. sp.

Plate 2, figs. 1 *a*-3 *b*

Description.—Shell large, depressed subglobular; columella solid. Surface of lower or first half of the last whorl ornamented by numerous revolving costae. Surface of upper or last half of whorl nearly smooth but bearing two rows of nodes which inclose the flat slit band.

The dimensions of the holotype are: length, 42 millimeters; breadth, 39 millimeters; and height, 31 millimeters. Judging from other specimens which have been sectioned it is composed of about five and one-half whorls. The shell forming the first two and one-half whorls is very thin but the thickness gradually increases with the growth of the shell. The rate of thickening becomes accelerated during the latter part of the third turn, and in the early part of the fourth turn a definite callosity of the inner lip becomes apparent and continues to just within the aperture of the shell. The two rows of nodes which outline the position of the slit band are not developed upon young individuals of about four and one-half turns. Such specimens also differ from the larger ones in their general contour, being more convex dorsally, and also in the conspicuous development of broken and irregular costae in the region of the columella.

In mature specimens the costae which ornament the lower or first half of the last whorl are low, rounded and rather uniform, but spaced somewhat unevenly. The shallow concave depressions which separate them may vary in width from a space about equal to the thickness of the costae to about twice this width. In advance of the callosity, the first 7 to 9 costae upon each side are regular and unbroken. Outside of these and occupying the surface to the edge of the columellar slope are other costae which are broken, offset, and arranged en echelon and in most cases not parallel to the inner regular ones. There is nothing to indicate the position of the slit band upon this part of the shell.

The revolving costae do not occur upon the upper or last half of the last whorl. Their line of termination is commonly U-shaped, being more advanced adjacent to the columellar slopes than in the center.

They are also elevated sharply above the flat and smooth surface of the forward portion of the whorl. Both of these features however are more strikingly developed in the young than in the mature shells.

The slit band is clearly shown extending down the center of the upper non-costate half of the outer whorl. It is broad and bears closely though unevenly spaced semicircularly concave growth lines. The greatest width of the band, developed near the aperture of the holotype, is nearly 4 millimeters. Upon either side of the slit band is a narrow flattened space equal to about half its width. The band and its bordering flat areas are inclosed between two rows of nodes extending from the point where the costae cease to the aperture. Although they vary considerably in size and shape they are rather uniformly spaced 4 to 5 millimeters apart and are commonly somewhat steeper toward the front and center.

The lateral surfaces of the forward part of the shell on either side of the double row of nodes bear very faint undulations which are preceptible only when light is reflected from this surface. These undulations form a series of broad revolving ridges and depressions which appear to continue from the costae of the earlier portion of the shell.

No nodes are developed along the borders of the slit band in the young specimens. In these the slit band is apparent as a narrow flat band, about ⅔ millimeter in width, which is sunk slightly below the general surfaces of the shell. It bears no growth marks and is similar to the band of some species of Carboniferous *Bellerophon*. The very faint revolving undulations on the lateral surfaces of the forward part of the shell are present upon some but not all of the young specimens. Where recognizable, however, they are much more widely spaced than are the following costae.

All specimens, both large or small, show growth lines only on the band.

The aperture is unexpanded and the shell thins abruptly to a very

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EXPLANATION OF PLATE 2

All figures natural size except 3 *b*

Euphemus callosus Weller, n. sp.

FIGS. 1 *a–e*.—The holotype. *a*, Top view; *b*, bottom view; *c*, side view; *d*, front view; *e*, top view showing original color pattern.

2 *a–c*.—Immature specimen. *a*, Top view; *b*, bottom view; *c*, side view.

3 *a–b*.—Section through the center of an immature specimen. *a*, Natural size; *b*, part of the same magnified four diameters.

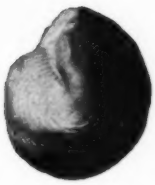
1a

1e

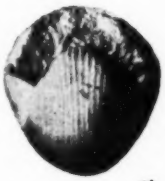
2a

1b

1c

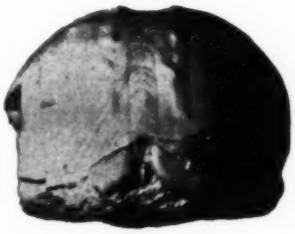


2c



2b

3b



1d

3a

delicate edge. The border of the aperture is nearly straight and curves in rather sharply to the shallow slit or sinus. At the columella the shell is turned strongly inward.

The shell is extraordinarily thick. One mature specimen that is broken shows that some 15 millimeters back from the border of the aperture, the shell is at least 3 millimeters thick.

A conspicuous and very thick callus is present just within the aperture. In the mature shells it is so thick that the lower part of the outer whorl is distinctly flattened and the whole shell appears to have been considerably compressed in a vertical direction. This callus attains a thickness equal at least to the thickness of the remainder of the shell, and in the larger individuals it may even be considerably thicker in proportion.

The outer edge of the callus is usually rather sharply marked off by a short steep slope, a comparatively smooth border, or by more or less interruption of the costae. This border is U-shaped and is furthest advanced adjacent to the columella, similar to the forward termination of the revolving costae described above. The U-shape is more pronounced in the small than in the large individuals. Along the outer edge of the callus the number of costae is approximately equal to the number beyond its margin. In large specimens additional costae are implanted between the others just within the aperture so that here the number of costae is twice as great as upon the outer portion of the shell. Such implantation of additional costae, however, has not been noted on the smaller individuals.

The color pattern preserved in these shells is most conspicuous along the slit band. The nodes bordering the area of the band are light gray. Just within each row of nodes occurs an irregular black stripe which is fairly sharply defined upon the outside and covers the flat zones upon either side of the band. The inner borders of the stripes are quite irregular and they encroach somewhat upon the band itself. The coloration of the lateral parts of the shell outside of the rows of nodes is much less striking. Here alternate light and dark bands swing backward at a considerable angle to the direction of the border of the aperture. The dark bands are given off rather uniformly from the bases of the nodes. The light bands originate in the internodal hollows but they become narrower and less well defined away from the band and gradually merge into the more uniform gray color of the sides of the shell.

The edge of the callus is marked in some specimens by a narrow dark band, sharp upon the outside but fading inwardly, which extends

from columella to columella. No coloration has been observed upon the costate portion of the shell.

The structure of the shell is plainly shown by a polished section cut through the center of a small individual (Plate 2, figs. 3 *a*, *b*). The coloration of this shell has been preserved and the various layers, due to their somewhat different composition, are sharply differentiated from each other. Six layers can be distinguished (see text figure). No. 3 is the central layer of the shell and on account of its darker color it stands out prominently from the rest. When carefully examined under the microscope this layer is seen to be composed of a series of overlapping plate-like parts, lenticular in cross-section and inclosed in a brown matrix. The lenticular masses have a radial structure. They are slightly lighter colored than the surrounding portion of layer 3 and contain large numbers of short, parallel, but

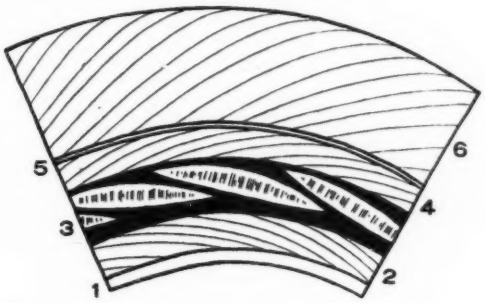


FIG. 1.—Diagrammatic section parallel to the plane of the spiral showing shell structure of *Euphemus callosus*.

irregularly sized and spaced dark areas, as though the darker material of this layer had filled the spaces between the calcareous fibers or elongated crystals which make up these masses. Layer 3 was developed very early in the shell and, throughout, it increases regularly and gradually in thickness. It was built up by deposition from the inside just within the opening of the aperture.

Layer 2 is light gray in color and occurs upon the inside of No. 3. It is composed of thin foreset layers which may be distinguished by their slight differences in shade. This layer thins out near the aperture and ceases some 10 to 12 millimeters from the edge of the outer lip. It was apparently built up from the inside just behind the growing portion of layer 3.

Layer 1 lines the inside of the shell. Its color is not uniform and can only be distinguished from No. 2 when it possesses a darker tint.

Its forward extent is about equal to that of No. 4 although it may extend farther forward as a very thin layer. No. 1 probably represents the nacreous lining of the shell.

Layer No. 4 is identical in appearance with No. 2 and is also composed of thin foreset layers. It thins adjacent to the aperture but the thin edge of this layer extends to the very margin of the outer lip. This layer was deposited upon the outside of No. 3 probably by an edge of the outer mantle which folded back over the lip of the aperture.

No. 5 is the thinnest of the layers. It is colored similarly to 2 and 4 and cannot be readily separated from 4. This layer however was deposited by the lower or posterior portion of the mantle which folded backward and over the body of the shell. This layer is the one which bears the parallel revolving costae characteristic of the genus *Euphemus*. Its border is situated about one-third of a volution behind the aperture.

Layer 6 is the callus. It is similar in composition and structure to Nos. 2 and 4, although the foreset structure of its tiny component layers is somewhat more abrupt. It also, like No. 5, was built by the inner or lower lobe of the mantle. This portion of the shell increases greatly in thickness in the last whorl or two. Its outer border is located about one-third of a turn behind the edge of No. 5.

Remarks.—Only two species representing the genus *Euphemus* have been described from the Pennsylvanian strata of the Mississippi Valley. These are *E. carbonarius* (Cox) and *E. nodocarinatus* (Hall). These two species closely resemble each other in most of their characters and it is doubtful if *E. nodocarinatus* could be recognized in the case of specimens from which the non-costate portion of the outer whorl has been broken away, as the broad shallow sinuses upon either side of the slit band appear to be the only means of differentiating it from the other species. A few other forms have been described from the Cordilleran region. It is unnecessary to consider them here as they resemble the two species mentioned above much more than they do *E. callosus*.

Euphemus callosus differs from all other known American species of *Euphemus* by the presence of a very thick callus just within the aperture. Descriptions of *E. carbonarius* and *E. nodocarinatus* commonly include a statement that a callus on the inner lip is either inconspicuous or absent. Our new species also differs in its thick and ponderous shell. Mature specimens may be distinguished from *E. carbonarius* by their much larger size, less globose shape, and the two rows of irregular nodes which bound the area of the slit band. Young

individuals differ in their coarser and more rounded costae and their much narrower slit band.

Large individuals of *E. callosus* are to be distinguished from *E. nodocarinatus* by the more conspicuous nodes which border the slit band, by the absence of the sinuses which characteristically occur on either side of the band in the latter species, and by the more depressed sub-spherical form. *E. callosus* is also ordinarily considerably larger than specimens of *E. nodocarinatus*. Young individuals may be recognized by the evenly rounded forward portion of the last whorl.

The immature and mature specimens of *E. callosus* differ so much from each other in form and ornamentation that if they had been collected from different localities, they might have been considered representative of different species. However, occurring as they do in close association and possessing certain characters in common which differ materially from all other known forms, there can be little doubt but that they are conspecific.

Occurrence.—The specimens were collected by J. R. Van Pelt, Jr., and G. H. Cady in the SW. ¼ NW. ¼ NW. ¼ sec. 13, T. 12 N., R. 10 W., Greene County, Illinois. The exact horizon from which they were obtained is not known, except that it is one of the three or four limestones which are commonly closely associated with coals Nos. 5 and 6 in this part of the State.

AN APPARATUS FOR THE REPRODUCTION OF SUTURE-LINES OF AMMONITES

By ANNA WOODWARD LUPHER, RALPH L. LUPHER and EARL L. PACKARD

An apparatus designed to reproduce the tracings of ammonite suture-lines on paper or smoked glass has been perfected at the laboratories of the University of Oregon and the California Institute of Technology. It represents an application of the pantograph principle developed largely by the junior authors while research assistants in Paleontology at the University of Oregon.

The perfected model as recently constructed by the junior authors at the southern institution has proved to be highly satisfactory, producing tracings that after but little experience on the part of the operator possess an accuracy surpassing that obtained by the usual methods. It is probable that it might be easily adapted for other uses involving reproductions of lines from curved surfaces.

The apparatus consists of two arms of equal length terminating in the recording and tracing styluses (designated in the figure as *rs* and *ts*), and balanced by the adjustable counter weights (*w*). These arms are connected to a rod (*r*) pivoted to the frame (*f*) which in turn swings on the column (*c*) attached to the base board. A thumb screw (*s*) locks this frame in any desired position. An auxiliary arm (*a*) is attached to the lower or recording arm and terminates in a pencil, or a guiding handle (*gh*). Any movement of that stylus is duplicated by the tracing stylus resting on the suture-line of the specimen and by the recording stylus moving upon the smoked glass (*sg*) below. The specimen is supported by a carriage sliding freely upon a track (*t*) and straddling the smoked glass plate and the recording stylus. The carriage is floored by a cardboard upon which the guiding stylus moves while following the suture-line of the specimen. The upright (*u*) supports the movable shelf (*ms*) which may be raised or lowered, and turned through 180° of vertical arc and clamped by the set screw (*ss*).

The procedure is simple, and excellent results can be obtained with a little practice. After a careful preparation of the suture-line, the ammonite is placed upon the movable shelf and fastened, unless too heavy, with plasticine and adjusted as to height before clamping. The stylus arms and the carriage are adjusted and the swinging frame clamped by the set screw. A smoked glass plate is then placed beneath the recording stylus in a proper position for tracing the entire suture, and a cardboard is placed above the glass on the carriage. Then the properly balanced upper stylus is adjusted to a starting point on the

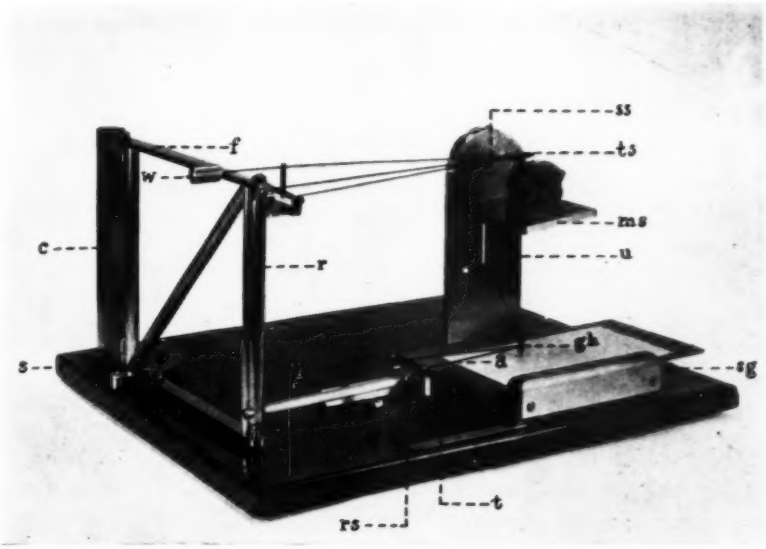


FIG. 1.—*f*, Frame; *c*, column; *w*, weight; *s*, thumb screw; *r*, rod; *ss*, set screw; *ts*, tracing stylus; *ms*, moving shelf; *u*, upright; *gh*, guiding handle; *a*, auxiliary arm; *rs*, recording stylus; *sg*, smoked glass plate; *t*, track.

suture-line which may then be followed accurately by means of the handle on the auxiliary arm below. From time to time it becomes necessary to carefully adjust the specimen shelf. With a little practice small changes can easily be accomplished without appreciable effect upon the tracing below. In tracing small ammonites a magnifier mounted above the specimen greatly facilitates the work. The amount of distortion is negligible and easily falls within the required limits. The tracing on smoked glass can be photographed, printed directly on photographic paper, or fixed by flooding carefully with a solution of resin dissolved in alcohol.

ENDOTHYRANELLA, A GENUS OF CARBONIFEROUS FORAMINIFERA

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ABSTRACT

Endothyranella, a genus belonging to the family Endothyridae, was derived from *Endothyra* by becoming evolute. The walls are calcareous and fibrous, and were secreted by the animal, as was the case with nearly all Paleozoic Foraminifera. At the end of its range, the walls may have sand grains added to the exterior, producing a form like *Ammobaculites*. The genus appeared in the Upper Mississippian, reached its maximum in the Middle Pennsylvanian, and became arenaceous in the Upper Pennsylvanian, when it seems to have become extinct. Nine species, three of which are synonyms, and ten possible species, are listed.

Several species of Foraminifera, which are like *Endothyra* in the early stages and evolute in the later stages, are now known from the Carboniferous, and their short ranges make them valuable as index fossils. We have proposed the name *Endothyranella* for these species, which were derived from Endothyra. The first species known was discovered by Brady, who included it under *Haplophragmium*, and during the past two years eight other species have been described and referred to *Ammobaculites*. These species do not agree in generic characters with either of the genera to which they have been referred.

Endothyranella has walls which were secreted by the animal, and are fundamentally calcareous and fibrous, like those of most Carboniferous genera, as *Endothyra, Globivalvulina, Orobias* and *Fusulinella*. The walls of most Paleozoic forms have been interpreted by most students of Foraminifera as being finely arenaceous with much calcareous or siliceous cement, an interpretation based on the poor preservation of the original structure of the walls, and on the mis-

taken postulate that arenaceous forms are more primitive than calcareous forms. According to that postulate, the walls ought to be arenaceous, for Paleozoic forms must be more primitive than later forms. *Haplophragmium* and *Ammobaculites,* which occur typically developed from Cretaceous to Recent, both have plainly arenaceous walls.

The coil of *Endothyranella* is composed of whorls which are added in a rotating plane, and are not planispiral, as has been stated in specific descriptions, whereas the coil of *Haplophragmium* is irregular, and that of *Ammobaculites* is planispiral. The aperture of *Endothyranella* is single, whereas that of *Haplophragmium* is multiple.

Typical *Endothyranella* occurs first in the Upper Mississippian, Yoredale limestone, of England, with one species, *E. recta* (Brady), which continues into the Upper Pennsylvanian, Hoxbar formation, of Oklahoma. Two species, *E. powersi* (Harlton) and *E. minuta* (Waters) occur in the Lower Pennsylvanian of Oklahoma, and three species, *E. compressa* (Cushman and Waters), *E. spirans* (Waters), and *E. nitida* (Waters), occur in the Middle Pennsylvanian of Michigan and Texas. Three described forms from the Middle Pennsylvanian of Texas, are synonyms of other species.

Three species identified as *Ammobaculites, A. stenomeca* Cushman and Waters, *A. suttonensis* Cushman and Waters, and *A. texturata* Cushman and Waters, occur in the Upper Pennsylvanian of Texas. These have arenaceous walls, and were probably derived from *Endothyranella.* If such forms were derived from *Haplophragmoides,* they are *Ammobaculites,* but if they result from the addition of sand grains to the calcareous walls of *Endothyranella,* they still belong to the latter genus, and are isomorphs of *Ammobaculites.* Partly arenaceous forms, which were definitely derived from calcareous forms by the addition of foreign grains to the outside of the walls, are retained in the genera from which they were derived, as are partly arenaceous species of *Sigmoilina, Quinqueloculina, Triloculina* and *Pyrgo.*

The following is a formal description of the genus:

Genus ENDOTHYRANELLA Galloway and Harlton, 1930

Endothyranella GALLOWAY and HARLTON, in Galloway and Ryniker, Oklahoma Geol. Survey, Circular 21, Jan., 1930, p. 13.

Genoholotype, *Endothyranella powersi* (HARLTON) = *Ammobaculites powersi* HARLTON, Journ. Pal., vol. 1, no. 1, 1927, p. 21, pl. 3, fig. 3. (Lower Pennsylvanian, Dornick Hills formation, Love Co., Okla.)

Test free, coiled in the early part, evolute and rectilinear in the

later part; the coil consists of about three whorls, with five to ten, slightly inflated chambers to a whorl, the plane of coiling rotating from 10° to 30° from the plane of the previous whorl, the earlier whorl or whorls partly or completely embraced by the last whorl, so that the coil appears nearly planispiral from the outside; umbilicate on one or both sides; chambers little or much inflated; peripheral margin rounded; sutures conspicuous, not limbate, the radial ones being straight or curved; wall calcareous, imperforate, opaque or translucent, not arenaceous, consisting of transverse fibers, much as in *Fusulinella* and *Fusulina,* which may become granular during fossilization or weathering, and appearing arenaceous on casual study; surface smooth, shiny, punctate, becoming roughened by weathering or by attachment of grains from the embedding rock; in the late Pennsylvanian, sand grains may be added to the surface, producing forms similar to *Ammobaculites;* aperture single, a high arch at the base of the septum in the coiled portion, gradually becoming central to the septum and finally terminal and round or oval in the evolute portion. Length, up to 2 mm.

Habitat.—Shallow water shales and limestones.

Range.—Upper Mississippian to Upper Pennsylvanian.

There are many stages found which are intermediate between *Endothyra* and *Endothyranella,* and it is usually difficult, sometimes impossible, to tell whether a specimen is an adult *Endothyra* or a young *Endothyranella.* Different species of both genera vary greatly in size, they coil the same way, and the aperture of an adult *Endothyra* may be a high arch, like the aperture of a young *Endothyranella.* The best criterion is to make an ontogenetic series from the young to the adult of specimens occurring in the same fauna. If an endothyrine form grades into typical *Endothyranella,* then the series of specimens are *Endothyranella.* If a series of endothyrine forms has no corresponding *Endothyranella* stage, then the specimens are likely *Endothyra.* There is as yet very little information on the differences between the megaspheric and microspheric forms of either *Endothyra* or *Endothyranella.*

The following species have been described which belong to *Endothyranella:*

Haplophragmium rectum Brady, Pal. Soc. Mono., 1876, p. 66, pl. 8, figs. 8, 9. Upper Mississippian, Yoredale ls., Yorkshire, England.

Ammobaculites powersi Harlton, Journ. Pal., vol. 1, no. 1, 1927, p. 21, pl. 3, fig. 3. Lower Pennsylvanian, Dornick Hills formation, Love Co., Okla.

Ammobaculites minuta Waters, Journ. Pal., vol. 1, no. 2, 1927, p. 133, pl. 22, fig. 3. Lower Pennsylvanian, Dornick Hills formation, Carter Co., Okla.

Ammobaculites compressa Cushman and Waters, Contrib. Cushman Lab. Foram. Res., vol. 3, pt. 2, 1927, pl. 22, fig. 2. Middle Pennsylvanian, Saginaw formation, Grand Ledge, Mich.

Ammobaculites spirans Cushman and Waters, Contrib. Cushman Lab. Foram. Res., vol. 3, pt. 3, 1927, p. 149, pl. 26, fig. 10. Middle Pennsylvanian, Upper Strawn formation, Erath Co., Texas.

Ammobaculites gracilis Waters, Journ. Pal., vol. 1, no. 4, 1928, p. 274, pl. 42, fig. 4. Middle Pennsylvanian, Canyon formation, Brown Co., Texas. A synonym of *E. spirans* (Cushman and Waters).

Ammobaculites nitida Waters, Journ. Pal., vol. 1, no. 4, 1928, p. 274, pl. 42, fig. 15. Middle Pennsylvanian, Canyon formation, Brown Co., Texas.

Ammobaculites inconspicua Cushman and Waters, Contrib. Cushman Lab. Foram. Res., vol. 4, pt. 2, 1928, p. 41, pl. 5, fig. 2. Middle Pennsylvanian, Canyon formation, Brown Co., Texas. A synonym of *E. recta* (Brady).

Ammobaculites stormi Cushman and Waters, Contrib. Cushman Lab. Foram. Res., vol. 4, pt. 2, 1928, p. 41, pl. 5, figs. 3, 4. Middle Pennsylvanian, Straw formation, Palo Pinto Co., Texas. A synonym of *E. nitida* (Waters).

The following species have highly arched or round apertures, and some of them are probably young specimens of *Endothyranella.*

Endothyra ameradensis Harlton, Journ. Pal., vol. 1, no. 1, 1927, p. 19, pl. 2, figs. 4 *a-c.* Middle Pennsylvanian, Deese formation, Carter Co., Okla.

Endothyra globulus Harlton (not Eichwald), ibid., p. 19, pl. 2, figs. 5 *a, b.* Middle Pennsylvanian, Deese formation, Carter Co., Okla.

Endothyra media Waters, Journ. Pal., vol. 1, no. 4, 1928, p. 273, pl. 42, figs. 11, 12. Middle Pennsylvanian, Canyon formation, Brown Co., Texas.

Endothyra grandis Waters, ibid., p. 273, pl. 42, figs. 13, 14. Middle Pennsylvanian, Canyon formation, Brown Co., Texas.

Endothyra ovata Waters, ibid., p. 274, pl. 42, figs. 6. Middle Pennsylvanian, Canyon formation, Brown Co., Texas.

Haplophragmoides marga Harlton, ibid., p. 306, pl. 52, figs. 4 *a, b.* Lower Pennsylvanian, Springer formation, Carter Co., Okla.

Haplophragmoides ciscoensis Harlton, ibid., p. 307, pl. 52, figs. 8 *a, b.* Upper Pennsylvanian, Cisco formation, Eastland Co., Texas.

The following species are arenaceous, and had best be retained in *Ammobaculites*, at least until their ancestry has been determined.

Ammobaculites stenomeca Cushman and Waters, Contrib. Cushman Lab. Foram. Res., vol. 4, pt. 2, 1928, p. 38, figs. 1 *a*, *b*. Upper Pennsylvanian, Graham formation, Young Co., Texas.

Ammobaculites suttonensis Cushman and Waters, Journ. Pal., vol. 2, no. 4, 1928, p. 360, pl. 47, figs. 6 *a*, *b*. Upper Pennsylvanian or Lower Permian, well in Sutton Co., Texas.

Ammobaculites texturata Cushman and Waters, ibid., p. 362, pl. 47, fig. 7. Upper Pennsylvanian, well in Sutton Co., Texas.

SOME EVOLUTIONARY STAGES OF PLATYSTROPHIA APPLIED IN CORRELATION OF CERTAIN ORDOVICIAN FORMATIONS

By BRADFORD WILLARD
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INTRODUCTION

With increased knowledge of stratigraphic methods and better correlation, means of determining the equivalence of formations are constantly being refined. Correlation based upon lithological resemblance is to be regarded with suspicion if corroborative paleontological evidence is lacking. In using fossils, correlation through agreement of a given percentage of species, matching faunas, or the use of index fossils, is sometimes unreliable in very careful work. The more precise method of applying evolutionary stages of a particular genus is here used.

METHOD AND APPLICATION

In correlation by evolutionary stages, a particular genus or perhaps family which runs through the series of formations being studied is selected. The stage of evolution peculiar to each horizon is accurately determined and then used in correlation. The finding of any one of these stages of evolution in a new area should determine quite accurately the horizon from which it came. The application in the present instance has been made to certain Ordovician formations in Tennessee and Kentucky. The material was collected by the Shaler Memorial Expeditions to the region and is now in the Museum of Comparative Zoölogy at Harvard University. The list of formations worked over follows:

TENNESSEE	KENTUCKY
Leipers	
Cathys	Cynthiana
	Woodburn
Bigby	Brannon
	Benson
Hermitage	Hermitage
Carters	Curdsville

The material at hand contains many brachiopods, a number of trilobites, and a few other invertebrate remains. Among these, the brachiopods seemed best suited to the problem, particularly the genus *Platystrophia*. This brachiopod was selected since it is represented by large numbers from most of the horizons, is easily recognized, and varies in a uniform manner along lines easily determined and plotted so that the respective stages are not hard to recognize. No examples of *Platystrophia* were collected from the Hermitage formation, and only a single individual was found in the Carters and Curdsville. Although this lone specimen fitted into the scheme nicely, it is here omitted. The formations beginning with the Bigby and Brannon horizon and ending with the Leipers are given most attention. Some three hundred or more individuals were measured. The measurements made on each were,

1. Width of shell (not along hinge-line)
2. Length of shell
3. Height of shell
4. Length of hinge-line
5. Depth of sinus
6. Width of sinus
7. Height of fold

Of these, the fourth, length of hinge-line, was discarded since in many specimens the cardinal extremities are missing through attrition. The fifth, sixth, and seventh measurements, depth of sinus, width of sinus, and height of fold, respectively, have also been discarded as unsatisfactory because of their variableness, particularly among later examples. The remaining dimensions were recorded and their averages taken for all the specimens from each horizon. It should be noted that the almost identical measurements of specimens from the Woodburn are combined with those from the Bigby and Brannon formations. No data were obtainable for the Benson.

MEASUREMENTS MADE UPON PLATYSTROPHIA

Formations	Width	Length	Height	Length-Width Index
Leipers	23 mm.	18 mm.	13.5 mm.	78%
Cathys-Cynthiana	19.5 mm.	14 mm.	12 mm.	72%
Bigby-Brannon and Woodburn	14 mm.	9 mm.	7 mm.	64%
Hermitage—No Platystrophias collected				
Carters-Curdsville—Insufficient data				

These figures represent, therefore, the dimensions of hypothetical, average, individuals from each horizon sufficiently well represented by specimens of the genus chosen. In correlation of any unassigned horizon with these, the average dimensions (width, length, and height) should be determined for a number of Platystrophias from that horizon. It is then reasonably certain that the unassigned formation, bed, or beds will be most nearly equal that of the above whose Platystrophias have the nearest average dimensions.

Evolution of Platystrophia

Considerable information on the many variations of the genus *Platystrophia* and its evolution is already available[1]. The following remarks serve to add to our knowledge of the genus from a rather restricted region. First, consider the dimensional changes. Comparing the Bigby and Brannon formations with the Cathys and Cynthiana, and then the Cathys and Cynthiana with the Leipers, and, finally, the Bigby and Brannon with the Leipers as to their Platystrophias, the following percentage changes in dimensions are noted:

PERCENT CHANGES IN DIMENSIONS OF PLATYSTROPHIA

Formations	Width Increase	Length Increase	Height Increase
Bigby and Brannon to Cathys and Cynthiana	39%	55%	72%
Cathys and Cynthiana to Leipers	18%	29%	13%
Bigby and Brannon to Leipers	64%	100%	93%

The figures show that there has been an increase in size along all three directions recorded, the greatest change being between the Bigby and Brannon to the Cathys and Cynthiana rather than between the Cathys and Cynthiana and the Leipers formations.

The dimensions were not the only variations shown by *Platystrophia*, although other features yield themselves less readily to applica-

[1] McEwan, E. D., Proceedings of the U. S. Nat. Mus., vol. 56, pp. 383-448, 1919.

tion in correlation. These features should be mentioned, however. Certain dimensions, incidentally, it will be recalled, were omitted as too variable. The length-width index falls off in the lower members. Among individuals higher up in the formations, more variations appear of a non-dimensional type. These changes were primarily related to sizes of sinus and fold and particularly to the number of plications in these two regions. Normally, there are four plications on the fold and three in the sinus, but as many as seven and six respectively were noted. Increase in size is marked, and at least one case of giantism was noted, a Leipers specimen, whose measurements were: Width, 43 mm.; length, 31 mm.; height 28.5 mm.; length-width index, 72%. This may be a phylogerontic individual or it may be pathological. Abnormally developed, unsymmetrical specimens are not uncommon among the more recent examples.

Summary

The foregoing data as far as the actual calculations of length, width and height go, are applicable in correlation among certain formations of the Ordovician of Tennessee and Kentucky. The area from which the specimens came is not large, but the problem deserves study since it may assist in unraveling some of the difficulties met in the Paleozoics of the region.

COMMON FORAMINIFERA OF THE EAST TEXAS GREENSANDS[1]

By JOSEPH A. CUSHMAN,
Sharon, Mass., and
NORMAN L. THOMAS,
Fort Worth, Texas

Our detailed study of Claiborne greensands of East Texas has been confined to outcrops east of the Trinity River starting with the type locality of the Mount Selman and the type locality of the Cooks Mountain. From these type localities where, unfortunately, microfossils are neither abundant nor well preserved, the junior author has followed the greensands to more prolific localities in the same general area where correlation is certain. We have felt that such a study should begin at the localities originally described and should extend only as far as correlation is sure and accurate. Certain characters have been so constant that mapping of formations has been possible throughout most of east Texas. Within this area the faunas should be those typical of Mount Selman and Cooks Mountain and it is such faunas that we are after rather than a hasty, distant correlation with south Texas, Louisiana, Mississippi or Alabama based upon a few samples. So far we have studied over a hundred surface samples from this area in east Texas.

As noted in our first set of descriptions in THE JOURNAL OF PALEONTOLOGY, June, 1929, weathering of greensands is very deep and is destructive to fossils due to the porosity of such formations, the insolubility of glauconite and the comparatively greater solubility of shells. Furthermore, the abundance of iron and iron-stained clay causes a brown coating to cover most of our fossils. Therefore, it has been difficult to find great numbers of surface localities with perfectly

[1] Published with permission of Chief Geologist of the Pure Oil Company.

preserved specimens. While well cores have many beautifully preserved Foraminifera and surface samples have few, we considered it advisable to confine this article to surface samples believing that it is better to use outcrops where other workers can collect material. As long as we can find satisfactory specimens in surface outcrops, we shall not use core material.

The purpose of this paper is to describe only species which are common in Mount Selman and Cooks Mountain greensands. Ranges as noted do not include those in other formations. The reasons for continuing the use of the names Mount Selman and Cooks Mountain, in spite of newer and more complicated nomenclature which is possibly better, are due to their use in our first paper, due to our policy of correlating with the two first described localities and also due to the distinctiveness in fauna of these two formations or groups of formations and to the general faunal uniformity within each group.

We are pleased to acknowledge indebtedness to Mr. George Weaver for collecting at the locality east of Grapeland and to Mr. Morrissey for collecting west of Centerville.

Family MILIOLIDAE

Genus QUINQUELOCULINA d'Orbigny, 1826

QUINQUELOCULINA YEGUAENSIS Weinzierl and Applin

Plate 3, figs. 1, 2

Quinqueloculina seminulum STADNICHENKO (not LINNÉ), Journ. Pal., vol. 1, no. 3, 1927, p. 226, pl. 38, fig. 28.

Quinqueloculina yeguaensis WEINZIERL and APPLIN, l. c., vol. 3, 1929, p. 393, pl. 44, figs. 4 *a*, *b*.

EXPLANATION OF PLATE 3

FIGS. 1, 2.—*Quinqueloculina yeguaensis* Weinzierl and Applin. ×55. *a*, *a*, *b*, *b*, Opposite sides; *c*, *c*, apertural views.

3 *a*, *b*.—*Triloculina trigonula* (Lamarck). ×55. *a*, Side view; *b*, apertural view.

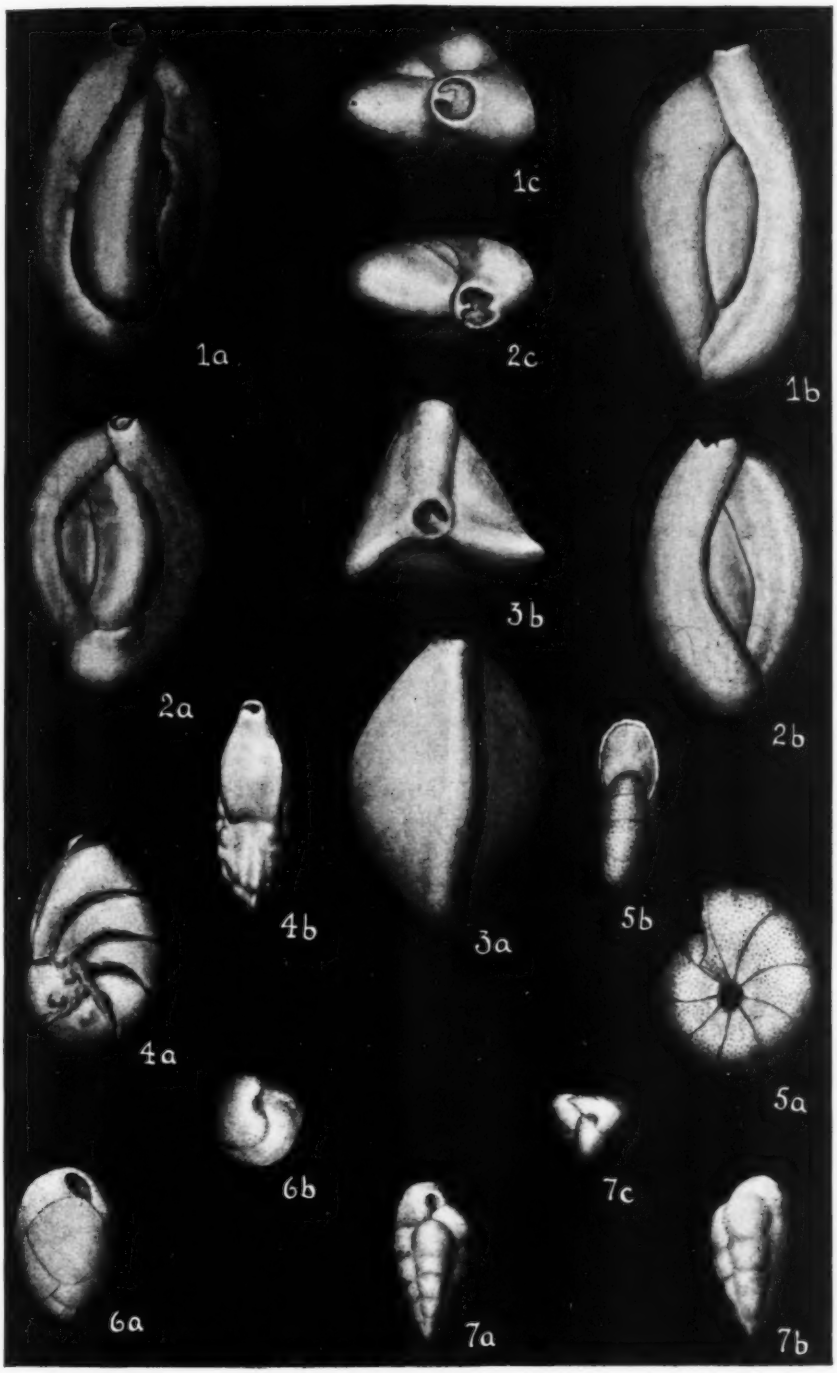
4 *a*, *b*.—*Robulus jugosus* Cushman and Thomas, n. sp. ×55. *a*, Side view; *b*, peripheral view.

5 *a*, *b*.—*Nonion planatum* Cushman and Thomas, n. sp. ×100. *a*, Side view; *b*, peripheral view.

6 *a*, *b*.—*Bulimina guayabalensis* Cole. ×100. *a*, Front view; *b*, apertural view.

7 *a*–*c*.—*Reussia subrotundata* Cushman and Thomas, n. sp. ×100. *a*, *b*, Opposite sides; *c*, apertural view.

Figures drawn by Margaret S. Moore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3b
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2b
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7c
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7a
7b

Test somewhat longer than broad, the apertural end somewhat exserted, periphery rounded; chambers quinqueloculine, somewhat inflated; sutures distinct, very slightly depressed; wall smooth; aperture nearly circular, not meeting the previous chamber, with a distinct apertural tooth, slightly expanded at the free end.

Specimens with neck, length, 0.84 mm.; maximum diameter, 0.50 mm.; minimum diameter, 0.39 mm. Specimens without neck, length, 0.70 mm.; maximum diameter, 0.48 mm.; minimum diameter, 0.28 mm.

The figured specimens are from the Mount Selman formation, four miles east of Grapeland, Houston County, Texas, and it is also found in the Cooks Mountain formation.

Genus TRILOCULINA d'Orbigny, 1826

TRILOCULINA TRIGONULA (Lamarck)

Plate 3, figs. 3 *a*, *b*

Miliolites trigonula LAMARCK, Ann. Mus., vol. 5, 1804, p. 351, no. 3; vol. 9, 1807, pl. 17, fig. 4.

Triloculina trigonula D'ORBIGNY, Ann. Sci. Nat., vol. 7, 1826, p. 299, no. 1, pl. 16, figs. 5-9; Modèles, 1826, no. 93.

Test in the adult with but three visible chambers, the angles rounded, last chamber overlapping both of the earlier ones, the periphery broadly convex, whole test somewhat longer than broad, in end view triangular, the sides slightly convex; sutures distinct; wall, smooth; aperture circular, with a rather broad, bifid tooth.

Length, 0.62-0.73 mm.; breadth, 0.45-0.50 mm.; thickness, 0.39-0.45 mm.

The figured specimen is from the Mount Selman formation at San Pedro Creek, Brown Farm on Angusta road, east of Grapeland, Houston County, Texas. It is also found in the Cooks Mountain formation. It is recorded by Weinzierl and Applin (Journ. Pal., vol. 3, 1929, p. 394).

Family LAGENIDAE

Genus ROBULUS Montfort, 1808

ROBULUS JUGOSUS Cushman and Thomas, n. sp.

Plate 3, figs. 4 *a*, *b*

Test close coiled, compressed, periphery acute and with a low blunt keel; chambers distinct, five to seven in the last-formed coil, the earlier ones somewhat obscured, later ones increasing gradually in

length; sutures somewhat limbate, slightly raised along the middle and proximal portions, earlier ones somewhat nodose or beaded, later ones smooth; wall smooth except for the nodes and raised sutures; aperture terminal, radiate at the upper angle of the peripheral face which is broad and slightly convex.

Maximum length, 0.50 mm.; breadth, 0.36 mm.; thickness, 0.22 mm.

Holotype (Cat. No. 371167, U. S. N. M.) from Cooks Mountain formation, Brookfield Bluff, 14 miles west of Crockett, on Trinity River, Texas.

This is a peculiar small species. It is related to *R. mexicanus* Cushman, but is less umbilicate and the chambers become larger and the sutures are differently curved. It is also close to *Robulus vacavillensis* (G. D. Hanna) from the Eocene of California, but is not so thick, and the chambers become more elongate. Its similarity in some points to *R. fragaria* (Gümbel), *R. subrostrata* (Münster) and to *R. baconica* (Hantken) may also be noted.

Family NONIONIDAE

Genus NONION Montfort, 1808

NONION PLANATUM Cushman and Thomas, n. sp.
Plate 3, figs. 5 *a*, *b*

Test planispiral, close coiled, compressed, bilaterally symmetrical, biumbilicate, periphery rounded; chambers distinct, but not inflated, about ten in the last-formed coil, which is almost completely involute, peripheral face of the last chamber convex; sutures distinct, earlier ones flush with the surface, later ones very slightly depressed, ending in a thickened ring about the umbilici; wall smooth, finely perforate; aperture a crescent-like slit at the base of the last-formed chamber.

Maximum diameter, 0.25 mm.; minimum diameter, 0.22 mm.; thickness, 0.11 mm.

Holotype (Cat. No. 371168, U. S. N. M.) from Cooks Mountain formation, three miles on main highway north of Bronson, Sabine County, Texas.

This is the same form that has been recorded by Weinzierl and Applin and by other authors as *Nonion umbilicatulum* (Montagu). The identification of Montagu's species is very doubtful, and this Middle Eocene species is not like those Recent ones from the region from which Montagu's types came, and so it seems best to give our form a different name.

Family BULIMINIDAE

Genus BULIMINA d'Orbigny, 1826

BULIMINA GUAYABALENSIS Cole

Plate 3, figs. 6 *a*, *b*

Bulimina guayabalensis COLE, Bull. Amer. Pal., vol. 14, no. 51, 1927, p. 24, pl. 1, figs. 1, 2.

Test small, triserial, compact, ovate, broadest toward the apertural end, rounded in end view; chambers few, increasing rapidly in size as added, of about four whorls, not much inflated; sutures slightly depressed, more so in the later portion; wall smooth, very finely perforate; aperture elongate, in a slightly depressed area.

Length of figured specimen, 0.22 mm.; diameter, 0.14 mm.

Our specimens may not have reached their full development. Compared with topotype material kindly supplied by Mr. W. S. Cole, they seem very similar and probably identical. Plate 1, fig. 1, of Cole's paper shows what seems to be the more normal form, and fig. 2 is evidently a somewhat doubtful specimen, if it is the same species.

Our figured specimen is from the Cooks Mountain formation, three miles north of Bronson, Sabine County, Texas.

Genus REUSSIA Schwager, 1877

REUSSIA SUBROTUNDATA Cushman and Thomas, n. sp.

Plate 3, figs. 7 *a-c*

Test small, triserial, tapering from the greatest breadth made by the last whorl to the sub-acute initial end, in end view triangular, the angles somewhat rounded; chambers very regular in position and in their gradual increase in size, slightly inflated; sutures distinct,

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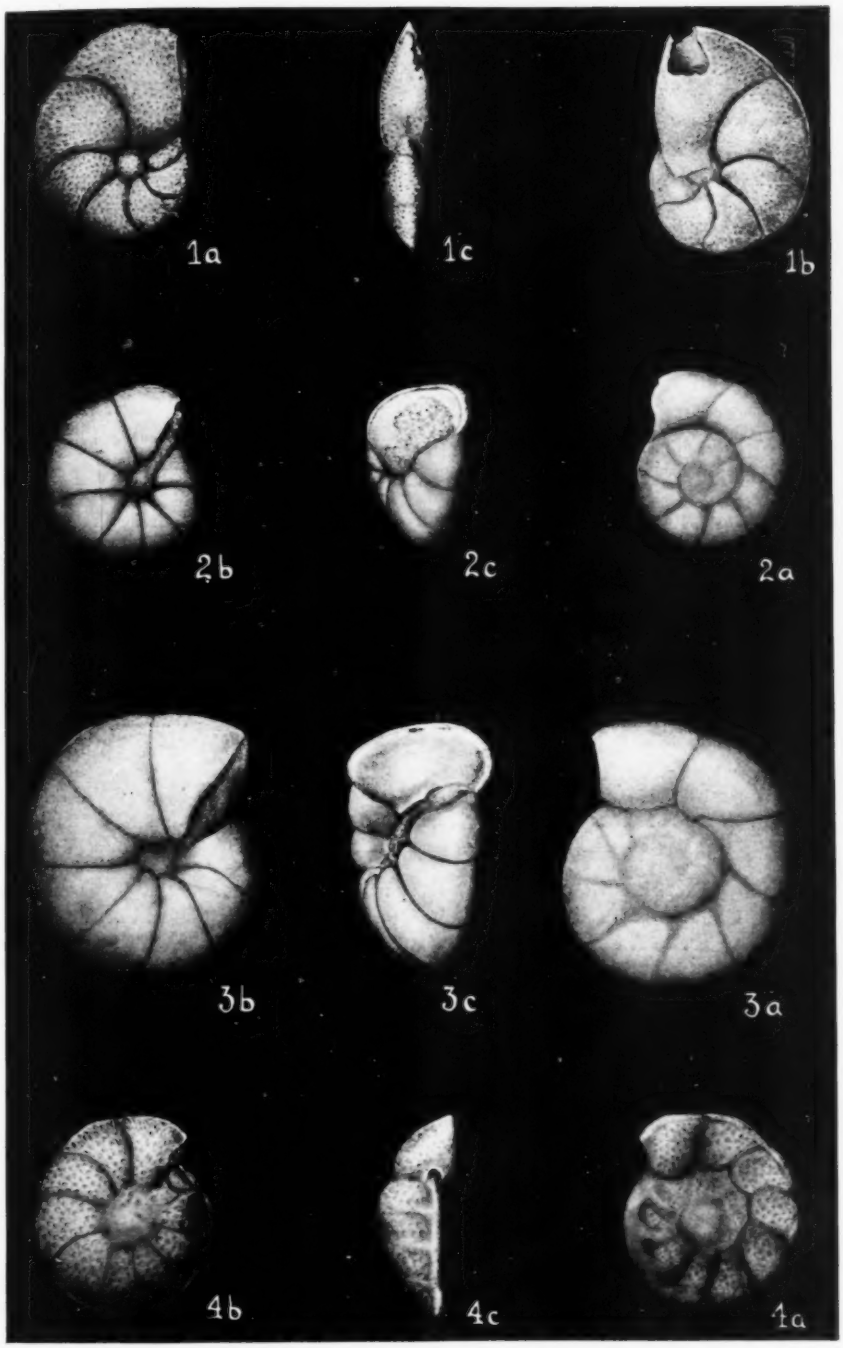
EXPLANATION OF PLATE 4

FIGS. 1 *a–c.*—*Discorbis yeguaensis* Weinzierl and Applin. ×90. *a*, Dorsal view; *b*, ventral view; *c*, peripheral view.

2, 3.—*Gyroidina soldanii* d'Orbigny, var. *octocamerata* Cushman and G. D. Hanna. ×100. Fig. 2, Young stage. Fig. 3, Adult. *a*, *a*, Dorsal views; *b*, *b*, ventral views; *c*, *c*, peripheral views.

4 *a–c.*—*Cibicides sassei* Cole (?). ×55. *a*, Dorsal view; *b*, ventral view; *c*, peripheral view.

Figures drawn by Margaret S. Moore


1a
1c
1b
2b
2c
2a
3b
3c
3a
4b
4c
4a

slightly depressed; wall smooth, finely perforate; aperture at the base of the inner margin of the last-formed chamber.

Length, 0.22 mm.; breadth, 0.11 mm.

Holotype (Cat. No. 371169, U. S. N. M.) from Cooks Mountain formation, three miles north of Bronson, Sabine County, Texas.

This is a small species with the angles not acute as in some of the more recent members of the genus, yet the end view is decidedly triangular.

Family ROTALIIDAE

Genus DISCORBIS Lamarck, 1804

DISCORBIS YEGUAENSIS Weinzierl and Applin

Plate 4, figs. 1 *a-c*

Discorbis yeguaensis WEINZIERL and APPLIN, Journ. Pal., vol. 3, 1929, p. 405, pl. 44, figs. 5 *a-c*.

This species has recently been described from the Yegua. It is common in the greensands of the Mount Selman and Cooks Mountain formations. Our figured specimen is from four miles east of Grapeland, Houston County, Texas.

Genus GYROIDINA d'Orbigny, 1826

GYROIDINA SOLDANII d'Orbigny, var. OCTOCAMERATA Cushman and G. D. Hanna

Plate 4, figs. 2, 3

Gyroidina soldanii D'ORBIGNY, var. *octocamerata* CUSHMAN and G. D. HANNA, Proc. Calif. Acad. Sci., 4th ser., vol. 16, no. 8, 1927, p. 223, pl. 14, figs. 16-18. —COLE, Bull. Amer. Pal., vol. 14, no. 51, 1927, p. 29, pl. 2, figs. 22-24.—CUSHMAN and SCHENCK, Univ. Calif. Publ., Bull. Dept. Geol. Sci., vol. 17, 1928, p. 312, pl. 44, figs. 3-5.—WEINZIERL and APPLIN, Journ. Pal., vol. 3, 1929, p. 406.

This variety which seems to be widely distributed in the early Tertiary of North America occurs commonly in the greensands of the Cooks Mountain and Mount Selman formations. Both young and adult specimens are figured from three miles north of Bronson, Sabine County, Texas.

Family ANOMALINIDAE

Genus CIBICIDES Montfort, 1808

CIBICIDES SASSEI Cole (?)

Plate 4, fig. 4 *a-c*

Test in the microspheric biconvex, in the megalospheric plano-convex, periphery sub-acute, with a thickened carina; chambers distinct, usually eight to ten in the adult whorl, increasing gradually in size as added, the last-formed one in the adult sometimes expanded somewhat; sutures distinct or gently curved, somewhat limbate, especially on the dorsal side, on the ventral side ending at the large central umbo, on the dorsal side becoming gradually thickened and fusing with the spiral suture and the surface of the earlier coils which are gradually raised with accretions of clear shell material; wall coarsely perforate; aperture narrow, at the peripheral margin, a rounded arch at the base of the chamber extending over onto the dorsal side and running along the periphery of the last-formed chamber.

Length, 0.53 mm.; breadth, 0.45 mm.; thickness, 0.22 mm.

Figured specimen from the Mount Selman formation at San Pedro Creek, Brown Farm, four miles east of Grapeland, Houston County, Texas. It also occurs in the greensand of the Cooks Mountain formation.

We have identified this with Cole's species described from the Eocene of Texas. Specimens from Mexico show much variation in the test in microspheric and megalospheric forms, the latter being plano-convex, and the former biconvex with gradations between. A similar series occurs in many species of *Cibicides*, both fossil and recent.

ARENACEOUS FORAMINIFERA FROM ORDOVICIAN AND SILURIAN LIMESTONES OF OKLAHOMA

W. L. MOREMAN
University of Kansas, Lawrence, Kansas

ABSTRACT

Thirteen genera and thirty species of arenaceous foraminifera have been discovered in samples of Arbuckle, Viola and Chimney Hill limestones from the Arbuckle Mountain region. The species belong to the described families Astrorhizidae, Rhizamminidae, Saccamminidae, Hyperamminidae, Ammodiscidae and the new family Stegnamminidae. A new subfamily is erected to include the two new genera, *Stegnammina* and *Raibosammina*. A new genus *Colonammina* assigned to family Saccamminidae is recognized. Altogether three new genera and twenty-seven new species are described.

The cementing material of these foraminifera has apparently been replaced by silica and they were removed, in a perfect state of preservation, from the hard crystalline limestone by dissolving it in hydrochloric acid.

INTRODUCTION

Fossil foraminifera in the Paleozoic are known almost exclusively from Carboniferous strata. Doubtful forms have been recorded from Precambrian quartzite in France by Cayeux; from the Cambrian in New Brunswick by Matthew, in the Malverns, England, by Chapman, in Russia by Ehrenberg; and from the Silurian by Brady, Terquem and Keeping. There are other scattered records but unquestionable species of early Paleozoic foraminifera are not abundant[1]. It has always been a surprising thing that the Ordovician, Silurian and Devonian, which are so prolific in beautifully preserved invertebrate remains, representing almost all classes, should be lacking in a good

[1] Cushman, J. A., Foraminifera their Classification and Economic Use, p. 42-44, 1928.

representation of foraminifera. This gap now is partially filled by the discovery of thirteen genera and thirty species of arenaceous foraminifera belonging to the described families Astrorhizidae, Rhizamminidae, Saccamminidae, Hyperamminidae, Ammodiscidae and the new family Stegnamminidae, in samples of Arbuckle, Viola and Chimney Hill limestones from the Arbuckle Mountains of Oklahoma.

In studying samples of these limestones, both in thin section and as a concentrate it is noteworthy that all of the foraminifera are of the arenaceous type. The calcareous species recorded from the lower Paleozoic of other regions are believed by Cushman[2] to have been wrongly identified or included in the Paleozoic through some error in labeling or otherwise. Calcareous foraminifera are, however, very typical of formations above the Paleozoic associated with the arenaceous forms.

The seeming absence of arenaceous foraminifera in the earlier geologic ages has been attributed to the fragility of the test which would not permit them to be extracted from consolidated sediments. Modern species are composed of sand grains, sponge spicules, tests of other foraminifera or mud cemented over a thin chitinous inner layer by a calcareous or ferruginous cement. They are usually abundant in dredgings taken from the cold waters of the present ocean and, also, the arenaceous forms, *Textularia, Bigenerina, Valvulina,* etc., are usually very abundant in shallow water tropical deposits. *Marsipella* is very abundant off the Florida coast at depths of a few fathoms. It is true that some arenaceous foraminifera are extremely abundant in very cold waters of high latitudes, but so are some calcareous forms[3].

The discovery of so many genera of foraminifera in Ordovician and Silurian strata, which have heretofore been found only in recent deposits, and with the apparent absence of calcareous forms, seems to substantiate theories advanced by Cushman as to primitive characters of the arenaceous foraminifera.

The first specimens were discovered in an insoluble residue of Chimney Hill made by Dr. J. W. Ockerman, of the State Geological Survey of Kansas, for the purpose of studying the heavy mineral content. He called attention to fragments in the sample which the writer recognized as parts of foraminiferal tests. This led to further investigation and the subsequent discovery of a rich faunule in the Chimney Hill and several species in the Viola and Arbuckle limestones.

The method used in extracting these delicate fossils from the hard crystalline limestone was to dissolve large pieces in fifty per cent

[2] Cushman, J. A., Personal communication.
[3] Cushman, J. A., Personal communication.

hydrochloric acid. The container was not moved except to drain off used acid and the large pieces of rock were taken out during this process.

Residues from Chimney Hill consisted of a small amount of clay, thin flakes of limonite, cubes of pyrite mostly altered to limonite and a small amount of sand other than that composing the foraminiferal tests. Residues from Viola and Arbuckle contained about the same materials except for a greater amount of sand. Several hundred specimens of foraminifera were dissolved out of a few small pieces of these limestones. Almost all were in a perfect state of preservation even to the most minute structures. Some, however, appear to have been mashed and twisted into various shapes so that in a few cases it was difficult to determine their true form.

The original calcareous cement of these fossil species has apparently been replaced by a siliceous cement, perhaps chalcedony. The writer has observed other types of foraminifera, as *Gümbelina* and *Anomalina* in samples concentrated from Eagle Ford shale, Cretaceous in age, that had been boiled in hydrochloric and nitric acids. It is apparent that these typically calcareous forms have been replaced by siliceous material.

The genera discovered in the Ordovician and Silurian show a geologic range greatly extended over former records. The following is a list showing the distribution as formerly known[4]:

Crithionina—Recent.
Bathysiphon—Cretaceous to Recent.
Psammosphaera—Jurassic to Recent.
Sorosphaera—Recent.
Lagenammina—Recent.
Thurammina—Carboniferous to Recent.
Tholosina—Recent.
Ammodiscus—Silurian to Recent.
Lituotuba—Carboniferous to Recent.
Hyperammina—Cambrian? Silurian to Recent.

Samples from three localities in the Arbuckle Mountains of Oklahoma were studied in detail.

Locality 1. Viola limestone, from rock quarry, at Bromide, Oklahoma.

Locality 2. Chimney Hill limestone, near the Burrow-Bromide road, north of Bromide, Oklahoma, T. 1 S., R. 8 E.

Locality 3. Arbuckle, Viola and Chimney Hill limestone, near

[4] Cushman, J. A., Foraminifera their Classification and Economic Use, 1928.

U. S. Highway 77, between Davis and Ardmore, Oklahoma, T. 2 S., R. 1 E., Carter Co., Okla.

It is planned to eventually deposit the type specimens, upon which this paper is based, in the U. S. National Museum.

Thanks are due Dr. Raymond C. Moore for helpful suggestions in the preparation of the manuscript and plates, Dr. K. K. Landes for collecting the first sample used in this study and Dr. J. W. Ockerman for collection of samples and suggestions in preparing the material for study.

DESCRIPTION OF SPECIES

Order FORAMINIFERA

Family ASTRORHIZIDAE

Genus CRITHIONINA Goës, 1894

CRITHIONINA RARA Moreman, n. sp.
Plate 5, figs. 7, 11

Test free, spherical, ellipsoidal or roughly polygonal; chamber small, distinctly subcavernous, the partitions being thin and irregularly arranged; wall thin and of varying thickness, composed of fine sand, surface rough and pitted; apertures indistinct; color white.

Diameter of figured specimens, 0.38 and 0.56 mm.

Occurrence.—Chimney Hill limestone. Locality No. 3.

Crithionina rara differs from other species of the genus by having a very thin wall and irregular subcavernous interior. It has the same general external appearance as *Crithionina pisum* Goës, but the latter has a thicker wall and is only slightly subcavernous.

Family RHIZAMMINIDAE

Genus BATHYSIPHON M. Sars, 1872

BATHYSIPHON CURVUS Moreman, n. sp.
Plate 5, figs. 9, 10

Test free, cylindrical, curved and distinctly tapering, in some specimens very slightly constricted at intervals; wall thin, composed mostly of very fine sand firmly cemented, surface smooth; apertures at the open ends of the tube; color white.

Length of figured specimens, 1.4 and 1.2 mm.

Occurrence.—Chimney Hill limestone. Locality No. 2.

BATHYSIPHON DEMINUTIONIS Moreman, n. sp.
Plate 5, fig. 6

Test free, cylindrical, curved, only slightly tapering, externally constricted; wall thin, composed of fine sand firmly cemented, surface smooth but uneven due to the constrictions; the test rapidly diminishes in diameter at each end so that the apertures are considerably less in diameter than the remainder of the test; color white.

Length of figured specimen, 0.7 mm.; diameter of test, 0.08 mm.; diameters of apertures, 0.04 and 0.06 mm.

Occurrence.—Chimney Hill limestone. Locality No. 2.

BATHYSIPHON EXIGUUS Moreman, n. sp.
Plate 6, fig. 8

Test free, cylindrical, slightly tapering, straight and very small; wall thin, composed of fine sand firmly cemented, surface smooth; apertures at the open ends of the tubes; color white.

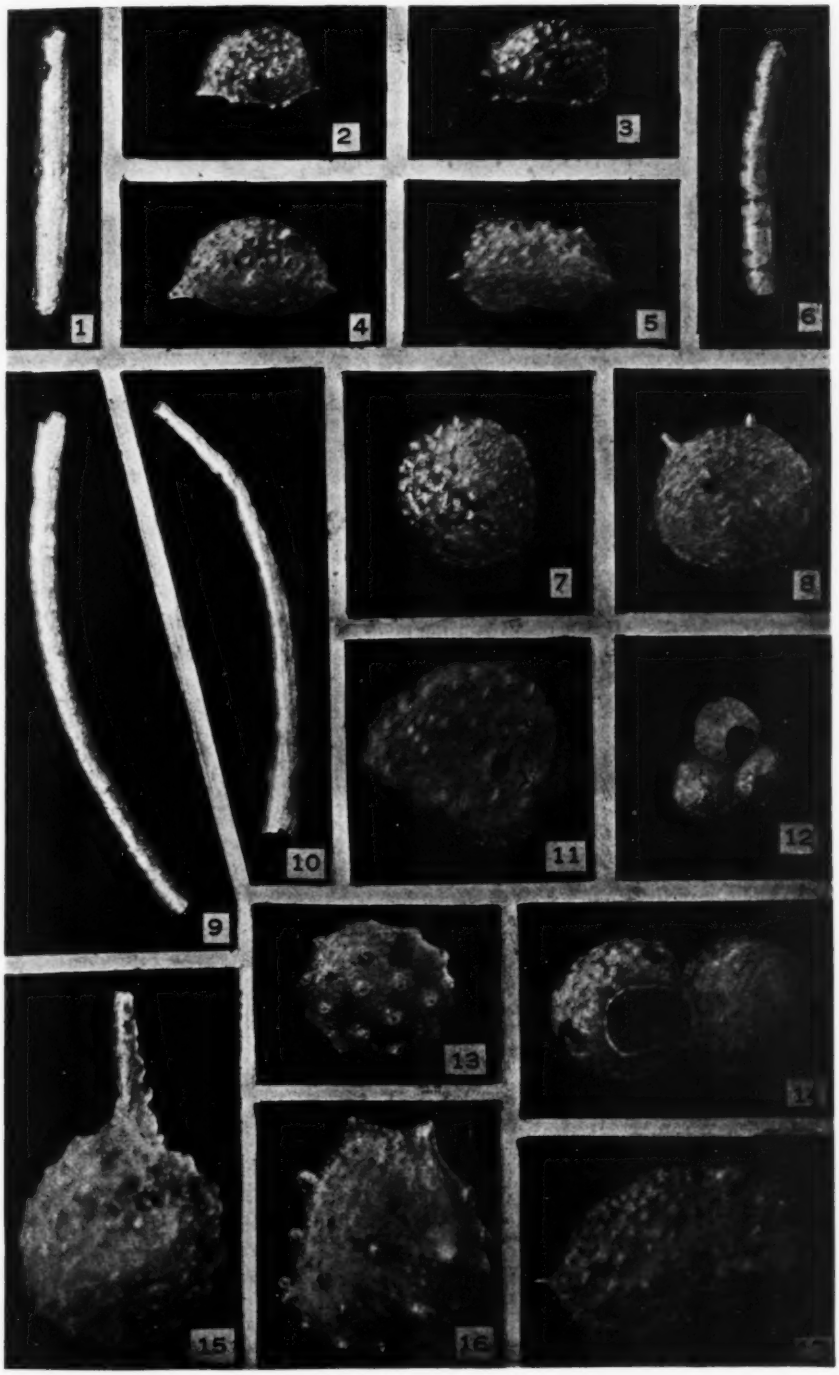
Length of figured specimen, 0.25 mm.

Occurrence.—Viola limestone. Locality No. 3.

With the discovery of these Ordovician and Silurian arenaceous foraminifera there have appeared forms which do not typically belong to any described family. It seems necessary, therefore, to erect a new family. In so doing we are including in it the subfamily Psammosphaerinae from family Saccamminidae. This subfamily includes spherical or subspherical forms without an aperture and they are not

EXPLANATION OF PLATE 5

FIG. 1.—*Hyperammina minuta* Moreman, n. sp. ×100.
2.—*Thurammina elliptica* Moreman, n. sp. ×50.
3.—*Thurammina phasela* Moreman, n. sp. ×50.
4.—*Thurammina elliptica* Moreman, n. sp. ×50.
5.—*Thurammina phasela* Moreman, n. sp. ×50.
6.—*Bathysiphon deminutionis* Moreman, n. sp. ×50.
7.—*Crithionina rara* Moreman, n. sp. ×50.
8.—*Thurammina tubulata* Moreman, n. sp. ×50.
9, 10.—*Bathysiphon curvus* Moreman, n. sp. ×50.
11.—*Crithionina rara* Moreman, n. sp. ×50.
12.—*Sorosphaera tricella* Moreman, n. sp. ×50.
13.—*Thurammina papillata* H. B. Brady. ×25.
14.—*Sorosphaera tricella* Moreman, n. sp. ×50.
15.—*Lagenammina sphaerica* Moreman, n. sp. ×75.
16.—*Thurammina subsphaerica* Moreman, n. sp. ×25.
17.—*Tholosina convexa* Moreman, n. sp. ×50.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typical of Saccamminidae which characteristically have one or more well developed apertures, or at least a definite zone along which the pseudopodia protrude, as in the case of *Webbinella*.

The new genera, making up another subfamily, have a test composed of a single closed chamber, cylindrical or subcylindrical in outline.

The systematic arrangement of the new family is as follows:

Family STEGNAMMINIDAE Moreman, new family

Subfamily PSAMMOSPHAERINAE Cushman

Genus PSAMMOSPHAERA F. E. Schultze, 1875

Genus SOROSPHAERA H. B. Brady, 1879

Genus STORTHOSPHAERA F. E. Schultze, 1875

Subfamily STEGNAMMININAE Moreman, new subfamily

Genus STEGNAMMINA Moreman, new genus

Genus RAIBOSAMMINA Moreman, new genus

Family STEGNAMMINIDAE Moreman, new family

Test free or attached, spherical, subspherical, cylindrical, subcylindrical, straight or irregularly branched; wall of varying thickness composed of arenaceous material, well to poorly sorted, usually firmly cemented; aperture lacking or indefinite.

Subfamily PSAMMOSPHAERINAE Cushman

Test spherical or subspherical, without a definite aperture.

Genus PSAMMOSPHAERA F. E. Schultze, 1875

PSAMMOSPHAERA CAVA Moreman, n. sp.

Plate 6, fig. 12

Test free, spherical; wall thin, composed mostly of fine sand grains, well cemented; aperture indefinite; color white.

Diameter of figured specimen, 0.5 mm.

Occurrence.—Chimney Hill limestone. Locality No. 3.

This species is very abundant in all of the samples studied. It is very close to *P. papyracea* (Cushman) but the latter has a thinner wall and is about twice as large.

Genus SOROSPHAERA H. B. Brady, 1897

SOROSPHAERA TRICELLA Moreman, n. sp.
Plate 5, figs. 12, 14

Test composed of three more or less spherical chambers attached in the same plane but each apparently independent of the others, the aggregate free; wall thin, composed of fine sand with much cement, surface smooth; apertures not apparent; color yellow or brownish.

Diameter of individual chambers in the two figured specimens, 0.18 and 0.36 mm.

Occurrence.—Chimney Hill limestone. Locality No. 2.

This species was present sparingly in every sample examined. The three-chambered aggregate seems to be a very dominant characteristic.

Subfamily STEGNAMMININAE Moreman, new subfamily

Test free or attached, cylindrical or subcylindrical, either straight or irregularly branched; without a definite aperture.

Genus STEGNAMMINA Moreman, new genus

Test free, a straight cylindrical or subcylindrical chamber; wall thin, composed of small to medium sized sand grains, well cemented; aperture indefinite.

Genotype *Stegnammina cylindrica* MOREMAN, n. sp.

STEGNAMMINA TRIANGULARIS Moreman, n. sp.
Plate 7, fig. 11

Test free, subcylindrical or somewhat triangular in cross section, ends slightly flattened; wall thin, composed of fine to medium sand grains well cemented, surface rough; aperture not apparent; color white.

Length of figured specimen, 1.04 mm.; width, 0.3 mm.

Occurrence.—Chimney Hill limestone. Locality No. 3.

STEGNAMMINA CYLINDRICA Moreman, n. sp.
Plate 7, fig. 12

Test free, cylindrical, ends slightly flattened; wall thin, composed of fine to medium sand grains well cemented, surface rough; aperture not apparent; color white.

Length of figured specimen, 0.76 mm.; diameter, 0.2 mm.

Occurrence.—Chimney Hill limestone. Locality No. 3.

This species differs from the above in its circular cross section and smaller size.

STEGNAMMINA HEBESTA Moreman, n. sp.
Plate 7, fig. 13

Test free, cylindrical but slightly tapering toward the ends, diameter about three-fourths the length, ends flattened and pitted; wall thin, composed of fine to medium sand grains well cemented, surface rough; color white.

Length of figured specimen, 0.84 mm.; diameter, 0.64 mm.

Occurrence.—Chimney Hill limestone. Locality No. 2.

Differs from the other two species in its irregular diameter and more robust character.

Genus RAIBOSAMMINA Moreman, new genus

Test free or attached, subcylindrical, straight, crooked or irregularly branched, interior of chamber not of uniform diameter; wall of unequal thickness, composed of poorly sorted sand grains; aperture not apparent.

Genotype *Raibosammina mica* MOREMAN, n. sp.

RAIBOSAMMINA MICA Moreman, n. sp.
Plate 6, figs. 7, 11

Test free but apparently attached in the early stages to a large sand grain, the larger specimens almost invariably have one large grain included in the test; chamber straight or slightly bent, comparatively small, interior irregular in diameter; wall of uneven thickness, composed of poorly sorted material, surface rough; aperture not apparent; color white or brownish.

Length of figured specimens, 0.74 and 0.76 mm.

Occurrence.—Viola limestone. Locality No. 1.

RAIBOSAMMINA ASPERA Moreman, n. sp.
Plate 6, figs. 13, 14, 15

Test free, subcylindrical; chamber crooked and irregularly branched, interior irregular in diameter; wall of uneven thickness, composed of poorly sorted material, surface rough; aperture not apparent; color white or brownish.

Length of figured specimens, 1.44, 0.7 and 1 mm.

Occurrence.—Viola limestone. Locality No. 1.

Family SACCAMMINIDAE

Subfamily SACCAMMININAE Cushman

Genus LAGENAMMINA Rhumbler, 1911

LAGENAMMINA SPHAERICA Moreman, n. sp.

Plate 5, fig. 15

Test free, small, bottle-shaped, that part of the chamber below the neck almost perfectly spherical, neck about two-fifths the length of the entire test; wall thin, composed of medium sand, surface rough; aperture circular at the end of an elongate neck; color white.

Length of figured specimen, 0.65 mm.; diameter, 0.38 mm.

Occurrence.—Chimney Hill limestone. Locality No. 2.

LAGENAMMINA STILLA Moreman, n. sp.

Plate 6, fig. 9

Test free, bottle-shaped, neck short, that part of the chamber below the neck more or less ellipsoidal in outline; wall thin composed of fine sand, surface smooth; aperture circular at the end of a short neck; color white.

Length of figured specimen, 0.44 mm.; width, 0.38 mm.

Occurrence.—Chimney Hill limestone. Locality No. 2.

Genus THURAMMINA H. B. Brady, 1879

Seven new species of this genus were obtained from the Chimney Hill limestone. The spherical or subspherical outline and the development of the apertures at the end of nipple-like projections are constant and characteristic. It seems that species formerly assigned to *Thurammina* which have indistinct apertures should be placed under *Psammosphaera*.

THURAMMINA PAPILLATA H. B. Brady

Plate 5, fig. 13

"Orbuline Lituola" W. B. CARPENTER, The Microscope, 5th ed., 1875, p. 553, fig. 273 g, h.

Thurammina papillata H. B. BRADY, Quart. Journ. Micr. Sci., vol. 19, 1879, p. 45, pl. 5, figs. 4-8.—CUSHMAN, Foraminifera, Their Classification and Economic Use, 1928, pl. 4, figs. 16-18 (after type figures).

Test free, spherical; wall thin, composed of fine sand with much cement, smoothly finished; apertures many, at the end of nipple like projections; color white or brownish.

Diameter of figured specimen, 0.84 mm.

Occurrence.—Chimney Hill limestone. Locality No. 2.

THURAMMINA TUBULATA Moreman, n. sp.
Plate 5, fig. 8

Test free, spherical; wall thin, composed of very fine sand with much cement, surface smooth; apertures circular and numerous at the end of well formed tube-like projections; color white.

Diameter of figured specimen, 0.44 mm.

Occurrence.—Chimney Hill limestone. Locality No. 3.

Thurammina tubulata differs from *T. papillata* in the character of the aperture, which is at the end of a well formed tube instead of a rounded nipple-like projection.

THURAMMINA SUBSPHAERICA Moreman, n. sp.
Plate 5, fig. 16

Test free, somewhat ellipsoidal in outline and slightly compressed; wall thin, composed of fine sand with much cement, surface smooth; apertures numerous and circular at the end of broad nipple-like projections, the nipples longer and more numerous around the borders; color brownish.

Length of figured specimen, 1.2 mm.; width, 1.08 mm.; thickness, 0.6 mm.

Occurrence.—Chimney Hill limestone. Locality No. 3.

T. compressa H. B. Brady is circular in outline and has the apertures developed only around the margins.

THURAMMINA IRREGULARIS Moreman, n. sp.
Plate 6, figs. 1, 5

Test free, usually single but sometimes attached in linear series, each independent of the other, chamber subspherical, the location of

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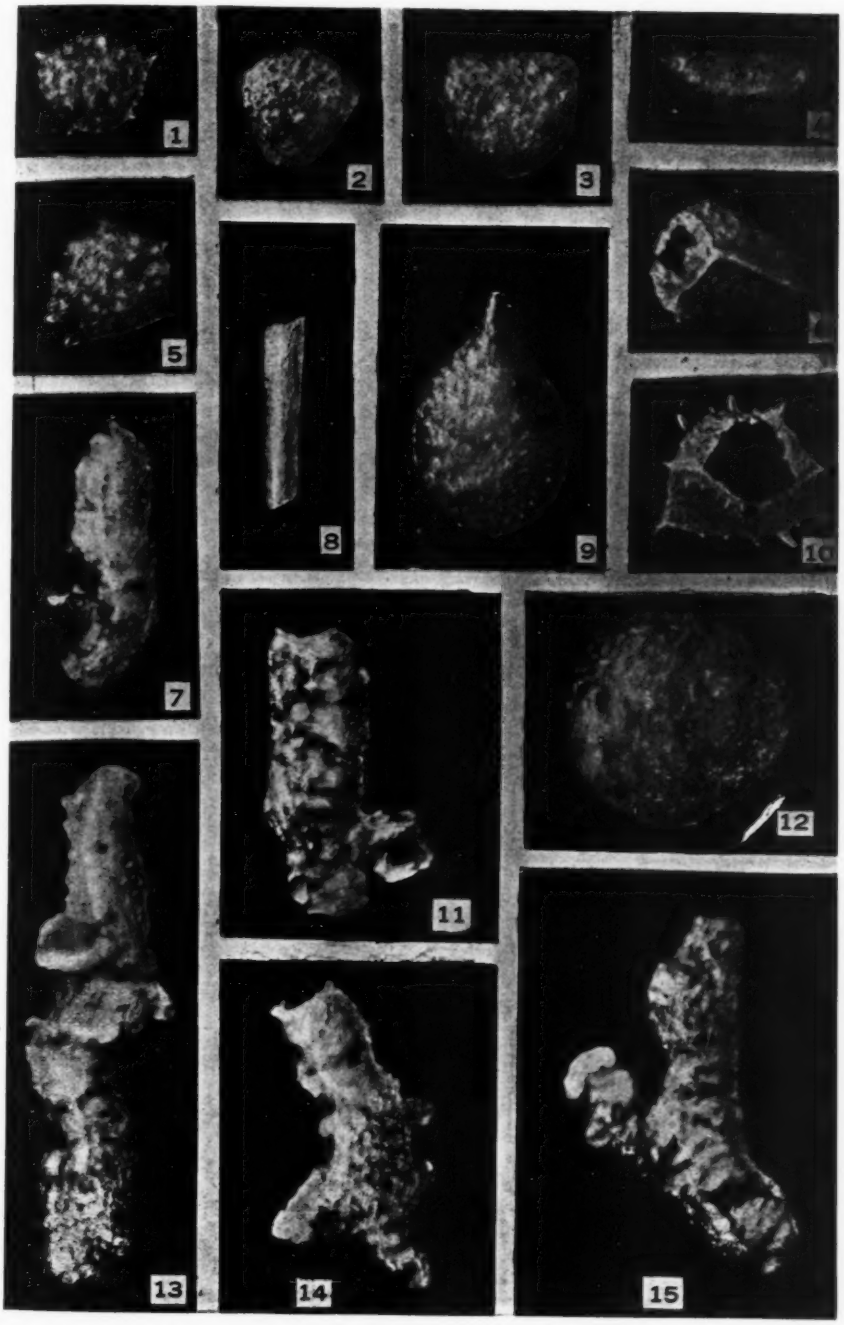
EXPLANATION OF PLATE 6

FIG. 1.—*Thurammina irregularis* Moreman, n. sp. ×50.
2, 3.—*Thurammina arcuata* Moreman, n. sp. ×50.
4.—*Tholosina elongata* Moreman, n. sp. ×50.
5.—*Thurammina irregularis* Moreman, n. sp. ×50.
6.—*Thurammina triangularis* Moreman, n. sp. ×50.
7.—*Raibosammina mica* Moreman, n. gen. et. n. sp. ×50.
8.—*Bathysiphon exiguus* Moreman, n. sp. ×100.
9.—*Lagenammina stilla* Moreman, n. sp. ×75.
10.—*Thurammina triangularis* Moreman, n. sp. ×50.
11.—*Raibosammina mica* Moreman, n. gen. et. n. sp. ×50.
12.—*Psammosphaera cava* Moreman, n. sp. ×50.
13–15.—*Raibosammina aspera* Moreman, n. gen. et. n. sp. ×50.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the apertures giving it an irregular outline; wall thin, composed of fine to medium sand well cemented; apertures few to many situated at the end of nipple-like projections which are variable in size and distribution; color white.

Diameter of figured specimens, 0.3 and 0.32 mm.

Occurrence.—Abundant in Chimney Hill limestone. Locality No. 3.

THURAMMINA TRIANGULARIS Moreman, n. sp.
Plate 6, figs. 6, 10

Test free, three or four sided, the sides being more or less triangular in outline; wall composed of fine sand well cemented; apertures at the end of tube-like projections situated along the somewhat carinate borders; color white.

Length of figured specimens, 0.4 and 0.4 mm.

Occurrence.—Chimney Hill limestone. Locality No. 2.

THURAMMINA PHASELA Moreman, n. sp.
Plate 5, figs. 3, 5

Test free, bean-shaped; wall thin, composed of fine sand well cemented; apertures numerous at the end of tube-like projections situated at the ends of the test, usually more numerous at one end; color white.

Length of figured specimens, 0.32 by 0.24 and 0.4 by 0.24 mm.

Occurrence.—Chimney Hill limestone. Locality No. 3.

THURAMMINA ELLIPTICA Moreman, n. sp.
Plate 5, figs. 2, 4

Test free, ellipsoidal; wall thin, composed of fine sand well cemented; one aperture on each end at the end of a tube-like projection; color white.

Length of figured specimens, 0.3 and 0.4 mm.

Occurrence.—Chimney Hill limestone. Locality No. 3.

THURAMMINA ARCUATA Moreman, n. sp.
Plate 6, figs. 2, 3

Test free, somewhat inflated, arcuate, triangular or polygonal in outline; wall thin, composed of fine sand with much cement, surface smooth; apertures at the end of broad to distinct nipples located along the margin of the test at the corners, two, three or four in number; color white.

Measurements of figured specimens, 0.32 by 0.34 and 0.34 by 0.36 mm.

Occurrence.—Chimney Hill limestone. Locality No. 2.

Subfamily WEBBINELLINAE Cushman

Genus THOLOSINA Rhumbler, 1895

THOLOSINA CONVEXA Moreman, n. sp.
Plate 5, fig. 17

Test attached, lower surface assuming the form of the object to which it is attached, upper surface convex, elliptical in outline; wall thin, composed of fine sand firmly cemented, surface rough; aperture single in the end of a tube-like projection along the border of the attached surface; color white.

Length of figured specimen, 0.74 mm.; width, 0.46 mm.

Occurrence.—Chimney Hill limestone. Locality No. 3.

Differs from *T. bulla* (H. B. Brady), in the outline of the test and the use of a smaller amount of cement. Only one specimen was obtained and the presence of a single aperture may or may not be characteristic of the species.

THOLOSINA ELONGATA Moreman, n. sp.
Plate 6, fig. 4

Test attached, flattened on the surface by which it is attached, chamber considerably elongated, straight on one side and curved on the other, upper surface flattened mostly towards one side so that a cross section would present an asymmetrical arch; wall comparatively thick for its size, composed of fine sand well cemented, surface rough; apertures three at the end of short protuberances at the line of the base on one end, the end on which the apertures occur slightly curved to one side; color white to yellowish.

Length of figured specimen, 0.43 mm.; width, 0.16 mm.

Occurrence.—Viola limestone. Locality No. 1.

Genus COLONAMMINA Moreman, new genus

Test attached, planoconvex, circular or elliptical in outline, attached surface surrounded by a more or less flattened border; wall thin, composed of fine sand well cemented; aperture single on the convex surface.

Genotype *Colonammina verruca* MOREMAN, n. sp.

COLONAMMINA VERRUCA Moreman, n. sp.
Plate 7, fig. 3

Test attached, planoconvex, elliptical or circular in outline, attached surface surrounded by a flattened border which is more distinct in some specimens than in others; wall thin, composed of fine sand well cemented; surface rough; aperture circular, situated at the end of a broad and short neck about the middle of the convex surface; color white.

Measurements of figured specimen, 0.33 by 0.29 mm.

Occurrence.—Chimney Hill limestone. Locality No. 3.

COLONAMMINA CONEA Moreman, n. sp.
Plate 7, figs. 1, 2

Test attached by two surfaces giving the chamber a wedge-shaped appearance, upper surface convex, somewhat elliptical in outline; wall thin, composed of fine sand well cemented; aperture circular, situated at the end of a broad and short neck about the middle of the convex surface; color white.

Measurements of figured specimens, figure 1, 0.32 by 0.17 mm.; figure 2, 0.32 by 0.24 mm.

Occurrence.—Chimney Hill limestone. Locality No. 3.

Family HYPERAMMINIDAE

Subfamily HYPERAMMININAE Cushman

Genus HYPERAMMINA H. B. Brady, 1878

HYPERAMMINA MINUTA Moreman, n. sp.
Plate 5, fig. 1

Test free, elongate, very small, consisting of a proloculum and tubular second chamber; wall thick, composed of very fine sand with

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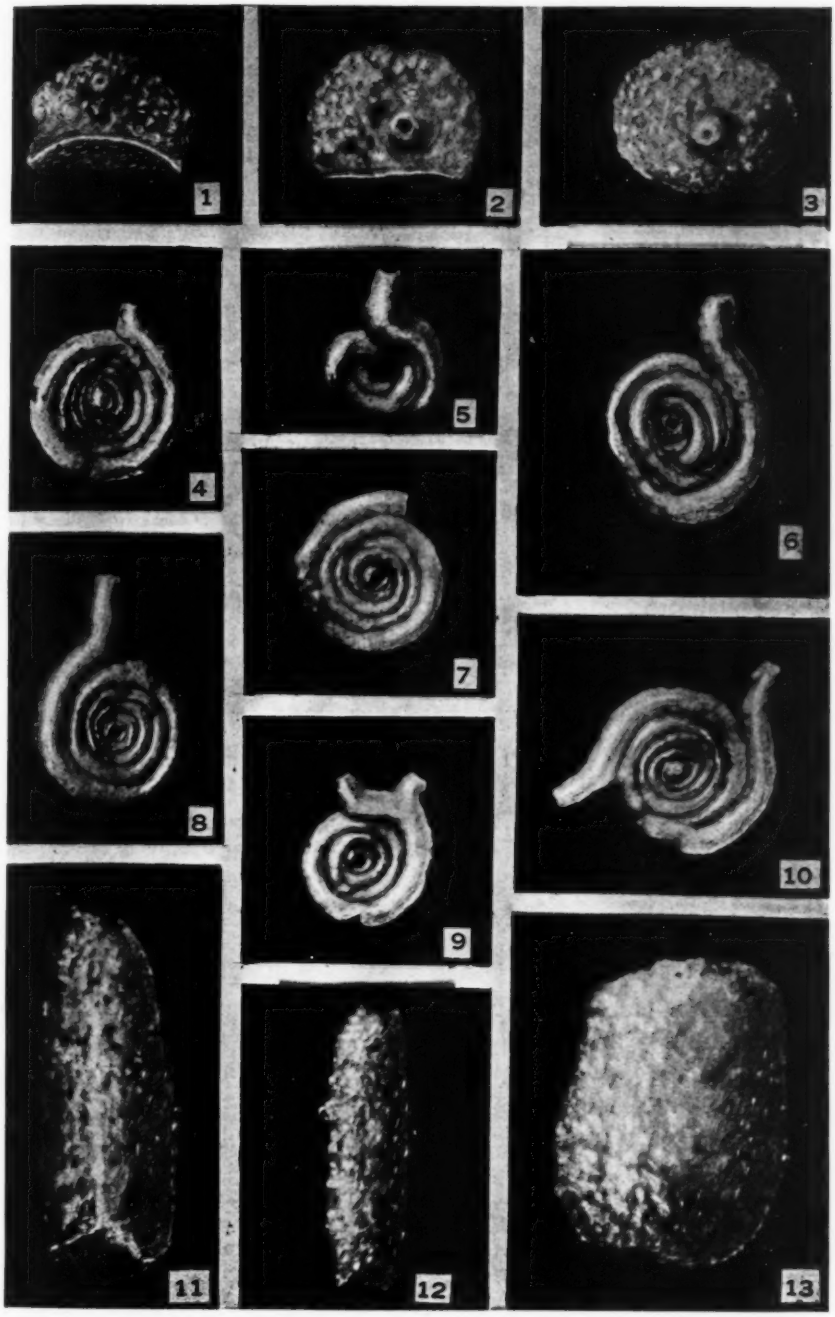
EXPLANATION OF PLATE 7

FIG. 1, 2.—*Colonammina conea* Moreman, n. gen. et. n. sp. ×75.
3.—*Colonammina verruca* Moreman, n. gen. et. n. sp. ×75.
4.—*Ammodiscus exsertus* Cushman. ×50
5, 6.—*Lituotuba exserta* Moreman, n. sp. ×50.
7.—*Ammodiscus incertus* (d'Orbigny). ×50.
8.—*Ammodiscus exsertus* Cushman. ×50.
9, 10.—*Ammodiscus? furca* Moreman, n. sp. ×50.
11.—*Stegnammina triangularis* Moreman, n. gen. et. n. sp. ×50.
12.—*Stegnammina cylindrica* Moreman, n. gen. et. n. sp. ×50.
13.—*Stegnammina hebesta* Moreman, n. gen. et. n. sp. ×50.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much cement, surface smooth and interior smoothly finished; aperture formed by the open end of the tube; color white.

Length of figured specimen, 0.4 mm.; diameter, 0.05 mm.

Occurrence.—Arbuckle limestone. Locality No. 3.

Two specimens of this species were obtained from the Arbuckle limestone. Its minute size makes its determination difficult, but one end is distinctly closed and there is a slight constriction just above the closed end which suggests a proloculum. The open end reveals a minute hollow tube with a very thick wall for its size. Under a high power microscope extremely fine sand grains are visible.

Family AMMODISCIDAE

Subfamily AMMODISCINAE Cushman

Genus AMMODISCUS Reuss, 1861

AMMODISCUS INCERTUS (d'Orbigny)

Plate 7, fig. 7

Operculina incerta D'ORBIGNY, in De la Sagra, Hist. Phis. Pol. Nat. Cuba, 1839, "Foraminifères", p. 49, pl. 6, figs. 16, 17; Spanish Edit., 1849, p. 71, pl. 6, figs. 16,17

Ammodiscus incertus H. B. BRADY, Rep. Voy. *Challenger*, Zoology, vol. 9, 1884, p. 330, pl. 38, figs. 1-3.

Ammodiscus incertus (D'ORBIGNY), Cushman, Foraminifera, Their Classification and Economic Use, 1928, pl. 9, figs. 1-4 (after type figures).

Test free, composed of an ovoid proloculum and long undivided second chamber, coiled regularly in one plane; wall finely arenaceous with much cement, surface smooth; aperture at the end of the tube; color white.

Diameter of figured specimen, 0.42 mm.

Occurrence.—Abundant in the Chimney Hill limestone. Locality No. 2.

The specimens occurring in the samples of Chimney Hill limestone examined are very small, ranging from 0.1 to 0.5 mm. and are all of white color. Recent forms range up to 6 mm. and are usually of a reddish or reddish-brown color.

AMMODISCUS EXSERTUS Cushman

Plate 7, figs. 4, 8

Ammodiscus exsertus CUSHMAN, Bull. 71, U. S. Nat. Mus., pt. 1, 1910, p. 75, figs. 97 *a*, *b* (in text); Bull. 100, U. S. Nat. Mus., vol. 4, 1921, p. 64, pl. 5, fig. 4.

Test free, consisting of an ovoid proloculum and tubular second

chamber close coiled for several revolutions, then uncoiling, but in the same plane, uncoiled portion straight, of varying length and usually turned at right angles to the direction of coiling; wall composed of fine sand with much cement, surface smooth; aperture at the end of the uncoiled portion, circular and slightly constricted; color white.

Diameter of figured specimens, 0.42 mm.

Occurrence.—Abundant in the Chimney Hill limestone. Locality No. 2.

The uncoiled portion of the Chimney Hill specimens turn at right angles to the direction of coiling while in the recent forms it turns at an angle less than 90 degrees.

AMMODISCUS? FURCA Moreman, n. sp.
Plate 7, figs. 9, 10

Test free, consisting of two chambers, a proloculum and second tubular chamber planispirally coiled, the second chamber at first a single tube but in the last coil dividing into two branches which grow out as straight tubes at once or continue to coil for part of a revolution before straightening out; in some the outer branch again divided into two, thus forming three tubes with apertures; wall composed of fine sand with much cement; two or three circular apertures at the ends of the branched second chamber, slightly constricted; color white.

Diameter of figured specimens, 0.32 and 0.48 mm.

Occurrence.—Chimney Hill limestone. Locality No. 2.

This species does not typically belong to genus *Ammodiscus* and on further study it may be described as a new genus.

Genus LITUOTUBA Rhumbler, 1895

LITUOTUBA EXSERTA Moreman, n. sp.
Plate 7, figs. 5, 6

Test free, consisting of a proloculum and tubular second chamber winding about its earlier coils in various planes, later portion uncoiling and extending as a straight tube about at right angles to the direction of coiling of the last convolution; wall of fine sand with much cement; aperture circular at the end of the straight portion, slightly constricted; color white.

Diameter of figured specimens, 0.34 and 0.48 mm.

Occurrence.—Chimney Hill limestone. Locality No. 2.

POST-MIOCENE FORAMINIFERA FROM THE VENTURA QUADRANGLE, VENTURA COUNTY, CALIFORNIA

Twelve New Species and Varieties from the Pliocene

By Roscoe E.[1] and Katherine C. Stewart
Ventura, California

Introduction

This paper is preliminary to a detailed study of post-Miocene foraminifera from the Ventura Quadrangle which we now have in preparation, and in which we hope to demonstrate the practical possibilities of micropaleontology in its application to a real geological problem. Such a study will involve working out the fauna, building up a control section, tying all important surface and well samples into the control section, and then combining the information so obtained with other available geological data for the purpose of unravelling the stratigraphic problem at hand.

To accomplish this purpose it may be necessary to include sections from outside the Ventura Quadrangle, those from the area lying between Aliso Canyon and Santa Paula Canyon in the Santa Paula Quadrangle and from the type locality of the Pico formation, for instance, but it is hoped that these will have been published by other authors by the time they are needed in our work.

The collecting of material for this work has been in progress since 1924, but has been done mostly since 1926 when several months were spent in Ventura working the geology of what is now the Rincon Oil Field for the Chanslor-Canfield Midway Oil Company.

[1] Collaboration by permission of Mr. F. C. Ripley, Manager, Chanslor-Canfield Midway Oil Company, Los Angeles, California.

The main body of post-Miocene sediments exposed in the Ventura Quadrangle lies along the Sulphur Mountain Overthrust fault and from there southward to the ocean. The face of the overthrust is marked for the most part by "Lower Pliocene" shales which have been faulted up along with Miocene and older formations and dragged under them as a result of overturn and thrusting. The sediments between the overthrust and the ocean are of Pliocene and Pleistocene age, and are thinly covered in places by Recent alluvial and beach deposits.

There has been some difference of opinion regarding the division of the Pliocene and Pleistocene column of this area, some workers[2] choosing to divide it into five formations, Santa Paula, Pico, Saugus, San Pedro and Hall Canyon, while others[3] favor a threefold division into Lower Pico, Upper Pico and Saugus. Although we shall follow the latter threefold division, at least in the beginning, it is not our purpose to take issue upon this question, and we shall not hesitate to recognize any system of division which future evidence may seem to vindicate[3a].

The Pico formation is assigned by Kew[4] to the lower Pliocene. In paragraph four of this introduction and later in the designation of localities for some of our species, the term "Lower Pliocene" is used in a somewhat different sense to designate strata which belong either in the lower part of the Lower Pico or altogether below it. A few workers have suggested correlating these strata with the Santa Margarita, although their large and very characteristic foraminiferal fauna shows marked Pliocene affinities.

The term "Lower Pliocene" as used in this sense is understood to have arisen among micropaleontologists working with California foraminifera. The fauna indicated is unquestionably very distinct and among the most easily recognizable of any with which we have to deal. Due, however, to the past usage of the term lower Pliocene, and the consequent meaning which it has come to have in the minds of most geologists and many paleontologists, considerable confusion seems to have arisen out of the attempt to apply it in this more restricted sense, and it is because of this confusion that we have thought

[2] Eaton, J. E., Geology and Oil Fields of Ventura Basin, Ventura County, California, Oil Age, vol. XXIII, No. 11, pp. 16-18, 1926; Divisions and Duration of the Pleistocene in Southern California, Bull. Amer. Assoc. Petrol. Geol., vol. 12, no. 2, pp. 111-141, 1928.

[3] Cartwright, Lon D., Jr., Sedimentation of the Pico Formation in the Ventura Quadrangle, California, Bull. Amer. Assoc. Petrol. Geol., vol. 12, no. 3, pp. 235-269, 1928.

3a Our attention was called to the following two publications bearing upon this question after it was too late to include them among the references of the original manuscript. Waterfall, Louis N., A Contribution to the Paleontology of the Fernando Group, Ventura County, California, Univ. Calif. Publ. Bull. Dept. Geol. Sci., vol. 18, pp. 71-92, 1929. Pressler, Edward D., The Fernando Group in the Las Posas-South Mountain District, Ventura County, California, Univ. Calif. Publ. Bull. Dept. Geol. Sci., vol. 18, pp. 325-345, 1929.

[4] Kew, W. S. W., Geology and Oil Resources of a Part of Los Angeles and Ventura Counties, California, U. S. Geol. Survey Bull. 753, p. 70, pl. III, 1924.

best to explain the meaning of the term as used in this paper. Several micropaleontologists are now working on the "Lower Pliocene", and it is to be hoped that it will eventually be more clearly defined, and that it will be designated by some term which shall be less generally confusing than the one here employed.

Among the foraminifera described as new in this paper are two varieties of the species *Gyroidina soldanii* d'Orbigny. For purposes of comparison figures drawn from one of d'Orbigny's original models of *G. soldanii* and reproductions of the only figures of that species which he ever published[5] are included in the plates.

We wish to acknowledge the kindness of Mr. Irvis W. Butterfield, geologist with the Richfield Oil Company of California, by whose permission core samples from that company's wells in the Rincon Field were made available for publication. Credit for the carefully drawn illustrations of our holotypes is due Miss Margaret S. Moore. For a careful checking of our specimens and descriptions and for the use of d'Orbigny's model and figures of *Gyroidina soldanii,* we are indebted to Dr. Joseph A. Cushman.

CYCLAMMINA CONSTRICTIMARGO R. E. and K. C. Stewart, n. sp.
Plate 8, figs. 1 *a*, *b*

Test comparatively large, close-coiled, compressed, umbilicate; periphery usually lobulated, constricted, commonly having the appearance of a thick keel although it is not actually carinate; chambers numerous, 15 or more in the last-formed coil, fairly distinct, slightly inflated, sometimes overlapping near the umbilical area; sutures slightly depressed, usually curved, the curvature commonly sigmoidal; wall finely arenaceous with much cement, smoothly finished but commonly with numerous coarse depressions rather evenly spaced representing the surface appearance of the interior labyrinthic structure, the outer wall of the test being relatively thin; the interior of the test labyrinthic; aperture a narrow arched slit at the base of the apertural face, with upper lip. Long diameter, 1.55 mm.; short diameter, 1.40 mm.; thickness, 0.45 mm.

Holotype (Cushman Coll. No. 12528) and paratypes (Stewart Coll. No. 507) from the Lower Pico at a drilling depth of 6,055 feet in the Miley H. & H. No. 1 well of the Richfield Oil Company of California, Rincon Oil Field, sec. 17, T. 3 N., R. 24 W., Ventura County, California.

Undistorted specimens of this species are rather rare, but the

[5] d'Orbigny, Alcide Dessalines, Foram. Foss. Bass. Tert. Vienne, p. 155, pl. VIII, figs. 10-12, 1846.

species itself is very common and a good marker in certain parts of the Lower Pico of the Ventura Basin. It is in many ways similar to *C. cancellata* H. B. Brady, but differs from that species in peripheral features, *C. cancellata* being decidedly rounded at the periphery and entire while our species is much constricted and is lobulate.

BULIMINELLA CURTA Cushman, var. BASISPINATA R. E. and K. C. Stewart, n. var.
Plate 8, fig. 6

Test spiral, tapering or fusiform, initial end bluntly pointed with a few small but distinct spines on the earliest chambers, thence increasing in diameter toward the broadest portion near the base of the last-formed chamber, periphery slightly lobulated; chambers numerous, 4 usually making up a coil in the adult, distinct, inflated; sutures distinct, somewhat depressed; wall smooth, very finely perforate; aperture comma-shaped in a depression of the face of the last-formed chamber, usually with a tooth or plate at one side. Length, 0.80 mm.; breadth, 0.30 mm.

Holotype of variety (Cushman Coll. No. 12574) and paratypes of variety (Stewart Coll. No. 508) from the Upper Pico shales exposed in Kalorama Canyon about 200 yards below its head. Kalorama Canyon is not named on the Ventura Quadrangle of the United States Geological Survey's topographic maps. It is the first canyon east of the lower course of Ventura River and emerges from the hills at the head of Kalorama Street, Ventura, California.

This variety is larger and more drawn out than typical *B. curta*, and differs also in having small but distinct spines on the earliest chambers.

BULIMINA PAGODA Cushman, var. HEBESPINATA R. E. and K. C. Stewart, n. var.
Plate 8, figs. 3 *a*, *b*

Test tapering, broadest at the base of the last-formed whorl of chambers, pointed at the initial end; chambers distinct, considerably cut under at the base, especially in the case of the later ones; periphery of the chamber with a series of stout, blunt spines projecting outward and downward, spines commonly as extensions of rather indistinct short costae which are occasionally broken up into irregularly arranged and indistinct double rows of blunt spines, several spines to each chamber; wall thin, translucent, finely perforate, otherwise smooth. Length, 0.40 mm.; breadth, 0.30 mm.

Holotype of variety (Cushman Coll. No. 12530) and paratypes of variety (Stewart Coll. No. 509) from the Lower Pico at a drilling

depth of 5,348 feet in the Miley H. & H. No. 1 well of the Richfield Oil Company of California, Rincon Oil Field, sec. 17, T. 3 N., R. 24 W., Ventura County, California.

This variety, which is a good marker for certain parts of the Lower Pico of the Ventura Basin, has the regularly tapering test and steeply sloping undercut later chambers characteristic of *B. pagoda*, but differs from that species in the decidedly blunt nature of the spines, which are also larger and stouter.

VIRGULINA NODOSA R. E. and K. C. Stewart, n. sp.
Plate 8, figs. 4 *a-c*

Test about three times as long as broad, greatest width near the apertural end which is broadly rounded in apertural view and sharply rounded in side view, tapering to a bluntly pointed initial end; chambers numerous, distinct, inflated, the early ones triserially spiral about an elongate axis, later ones more or less irregularly biserial, the last three making up half or slightly more than half of the test; sutures distinct, considerably depressed; wall smooth but distinctly perforate; aperture a comma-shaped opening in a depression of the inner face of the last-formed chamber. Length up to 0.35 mm.; breadth, 0.13 mm.; thickness, 0.11 mm.

Holotype (Cushman Coll. No. 12532) and paratypes (Stewart Coll. No. 510) from "Lower Pliocene" shales exposed in a road cut at Rin-

EXPLANATION OF PLATE 8

FIGS. 1 *a, b.*—*Cyclammina constrictimargo* R. E. and K. C. Stewart, n. sp. ×35. *a*, Side view; *b*, apertural view.

2 *a, b.*—*Pullenia salisburyi* R. E. and K. C. Stewart, n. sp. ×100. *a*, Side view; *b*, apertural view.

3 *a, b.*—*Bulimina pagoda* Cushman, var. *hebespinata* R. E. and K. C. Stewart, n. var. ×100. *a*, Side view; *b*, apertural view.

4 *a–c.*—*Virgulina nodosa* R. E. and K. C. Stewart, n. sp. ×100. *a, b*, Side views; *c*, apertural view.

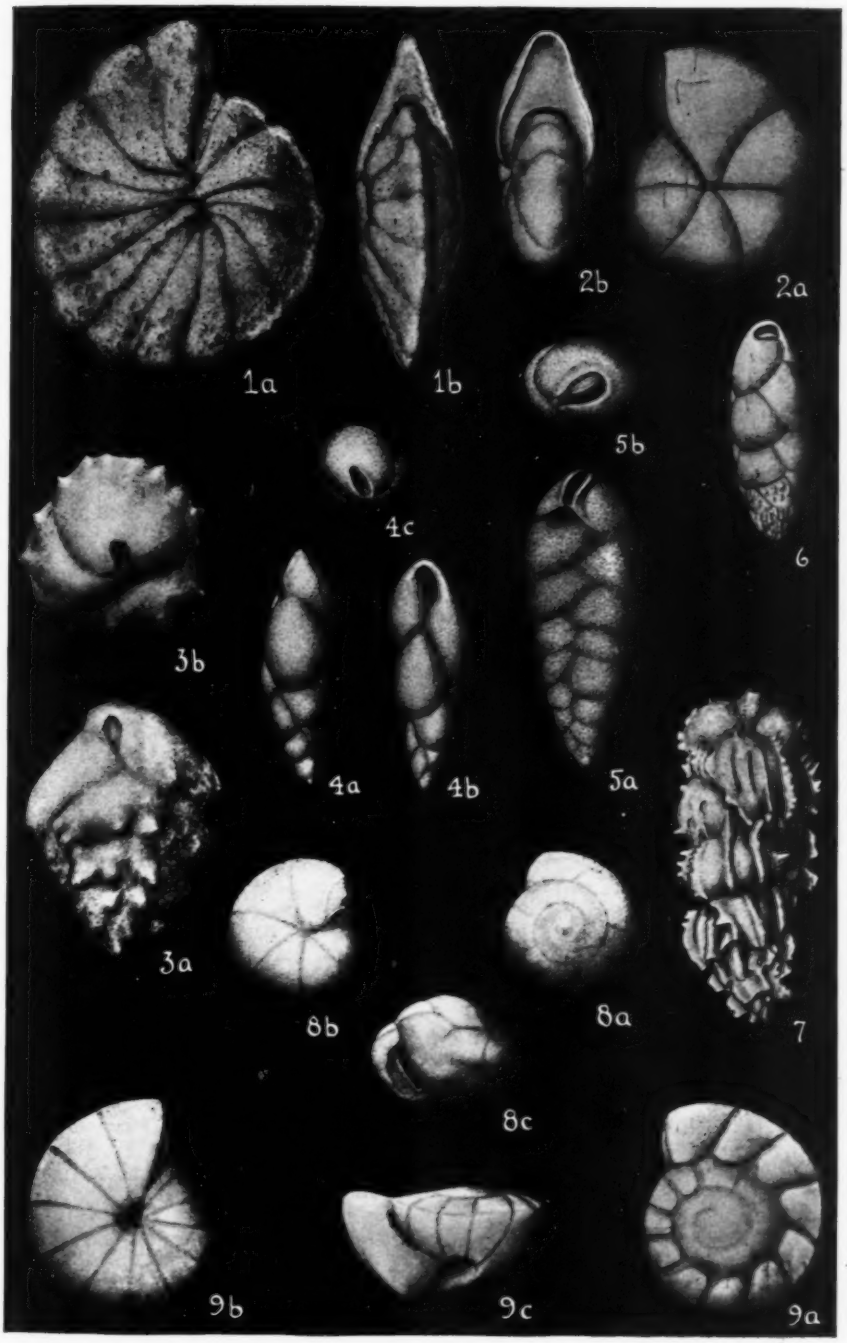
5 *a, b.*—*Bolivina seminuda* Cushman var. *foraminata* R. E. and K. C. Stewart, n. var. Megalospheric form. ×60. *a*, Front view; *b*, apertural view.

6.—*Buliminella curta* Cushman, var. *basispinata* R. E. and K. C. Stewart, n. var. ×40.

7.—*Uvigerina peregrina* Cushman, var. *latalata* R. E. and K. C. Stewart, n. var. ×60.

8 *a–c.*—*Eponides healdi* R. E. and K. C. Stewart, n. sp. ×60. *a*, Dorsal view; *b*, ventral view; *c*, peripheral view.

9 *a–c.*—*Gyroidina soldanii* d'Orbigny. (After d'Orbigny's Model.) *a*, Dorsal view; *b*, ventral view; *c*, peripheral view.


1a
1b
2b
2a
5b
4c
6
3b
4a
4b
5a
3a
8b
8a
7
8c
9b
9c
9a

con Point about 150 yards east of the Ventura County line along the highway from Ventura to Santa Barbara, Ventura County, California.

The depressed sutures together with the inflation and somewhat irregular arrangement of the chambers gives to this species a knotty or knobby appearance which has suggested the name *nodosa*. This knobby appearance together with the distinctly inflated chambers, the rather rapid increase in width, the peculiar flattening of the apertural face and the somewhat sharp apex seem to be distinctive characters.

BOLIVINA SEMINUDA Cushman, var. FORAMINATA R. E. and K. C. Stewart, n. var.
Plate 8, figs. 5 *a*, *b*

Test elongate, subcylindrical, very slightly depressed; initial end rounded in the megalospheric form, bluntly pointed and commonly twisted in the microspheric form; chambers numerous, high, very slightly inflated, more so in the megalospheric than in the microspheric form; sutures very slightly depressed, distinct; wall hyaline, lower approximately ⅔ of each chamber coarsely perforate and whitish in color, remainder finely perforate, clear and transparent, clear portion usually completely covered by succeeding chambers except in the last 2 or 3 chambers of matured specimens; aperture elongate, loop-shaped. Length up to 0.80 mm.; breadth, 0.30 mm.; thickness, 0.24 mm.

Holotype of variety (Cushman Coll. No. 12533) and paratypes of variety (Stewart Coll. No. 511) from Lower Pico shales exposed along the coast east and north of Pitas Point, SE. ¼ sec. 22, T. 3 N., R. 24 W., Ventura County, California.

This variety is evidently an ancestral form of *B. seminuda*, with the "nude" portions reduced and the coarsely perforate or foraminate areas larger.

UVIGERINA PEREGRINA Cushman, var. LATALATA R. E. and K. C. Stewart, n. var.
Plate 8, fig. 7

Test elongate, 2 to 2½ times as long as broad, widest portion varying between the middle and the apertural end, ends rounded; chambers fairly numerous, inflated, distinct; sutures depressed; wall ornamented with longitudinal costae, usually 5 or 6 on a full grown chamber, which are discontinuous from chamber to chamber and usually so offset as to line up with the intracostal spaces of adjacent chambers, high and very thin and characteristically somewhat broadly spread out like a wing or fan with scalloped edges, toward the apertural end

of the test becoming broken up into spinose or irregular short portions; the wall between the costae varying from granular to smooth; aperture circular at the end of a distinct cylindrical neck, often finely spinose and with a phialine lip. Length up to 0.85 mm.; breadth up to 0.40 mm.

Holotype of variety (Cushman Coll. No. 12535) and paratypes of variety (Stewart Coll. No. 512) from the Upper Pico of the mud pits at the Dent Mud Plant about 1½ miles north of Ventura and ½ mile east of Ventura Avenue at the head of Franklin Lane, Ventura County, California.

This variety is distinguished by its high, thin, broad-winged or fan-shaped scalloped-edged costae.

GYROIDINA SOLDANII d'Orbigny, var. ALTIFORMIS R. E. and K. C. Stewart, n. var.
Plate 9, figs. 2 *a-c*

Test trochoid, plano-convex, dorsal side flattened and grooved, ventral side strongly convex with deep umbilicus, peripheral edge very slightly rounded; chambers numerous, distinct, usually ten or eleven in the last-formed coil of adult specimens and eight or nine in that of younger specimens; later chambers with dorsal faces tilted backward, early chambers covered by an umbonate growth which probably masks a similar tilting of their dorsal faces; sutures distinct, limbate, on the ventral side usually somewhat depressed around the umbilicus and much less so near the periphery, on the dorsal side raised in the later chambers due chiefly to the tilting of the chamber faces, dorsal sutures oblique; wall smooth, thick, finely perforate; aperture an elongate slit at the inner margin of the ventral side. Diameter up to 0.75 mm.; depth up to 0.45 mm.

Holotype of variety (Cushman Coll. No. 12537) and paratypes of variety (Stewart Coll. No. 513) from the Upper Pico of the mud pits at the Dent Mud Plant about 1½ miles north of Ventura and ½ mile east of Ventura Avenue at the head of Franklin Lane, Ventura County, California.

The types for this variety have been compared with d'Orbigny's Model and with a large series of Recent and Tertiary specimens of *G. soldanii,* and do not appear to be specifically distinct from it. Varietal distinction is drawn upon the deep form, the raised dorsal sutures, and the persistance of a peculiar backward tilting of the dorsal faces of the later chambers which, however, is also sometimes seen in *G. soldanii.*

GYROIDINA SOLDANII d'Orbigny, var. ROTUNDIMARGO R. E. and K. C. Stewart, n. var.
Plate 9, figs. 3 *a-c*

Test trochoid, plano-convex, dorsal side flattened and may be slightly rounded, ventral side strongly convex with deep umbilicus, peripheral edge decidedly rounded; chambers numerous, indistinct, usually 12 in the last-formed coil of adult specimens; sutures indistinct, very slightly depressed, dorsal sutures nearly at right angles to the direction of coiling; wall smooth, finely perforate; aperture an elongate slit at the inner margin of the ventral side. Diameter up to 0.45 mm.; depth up to 0.38 mm.

Holotype of variety (Cushman Coll. No. 12540) and paratypes of variety (Stewart Coll. No. 514) from the Lower Pico at a drilling depth of 3,045 feet in the Miley H. & H. No. 1 well of the Richfield Oil Company of California, Rincon Oil Field, sec. 17, T. 3 N., R. 24 W., Ventura County, California.

This variety is distinguished from *G. soldanii* and from the variety *altiformis* by its more rounded periphery, its greater number of chambers, the indistinct appearance of its chambers and sutures, the nonlimbate nature of its sutures, and the practically normal (in a geometrical sense) attitude of its dorsal sutures to the direction of coiling. Although specimens of this form are rather common, unbroken and undistorted specimens are very rare. In the one figured on plate 9 the typical rounded nature of the periphery is indicated only on the left hand side of figure 3 *c* as shown.

We have specimens from the Upper Pico which appear to belong to this variety, but which differ very slightly in having a somewhat sharper periphery and a tendency for the sutures to become limbate.

Cushman[6] has noted Recent specimens from off the west coast of America which doubtless also belong to this variety.

[6] Cushman, J. A., Recent Foraminifera from off the West Coast of America, Bull. Scripps Instit. Oceanography, Tech. Ser., vol. 1, no. 10, p. 162, 1927.

EXPLANATION OF PLATE 9

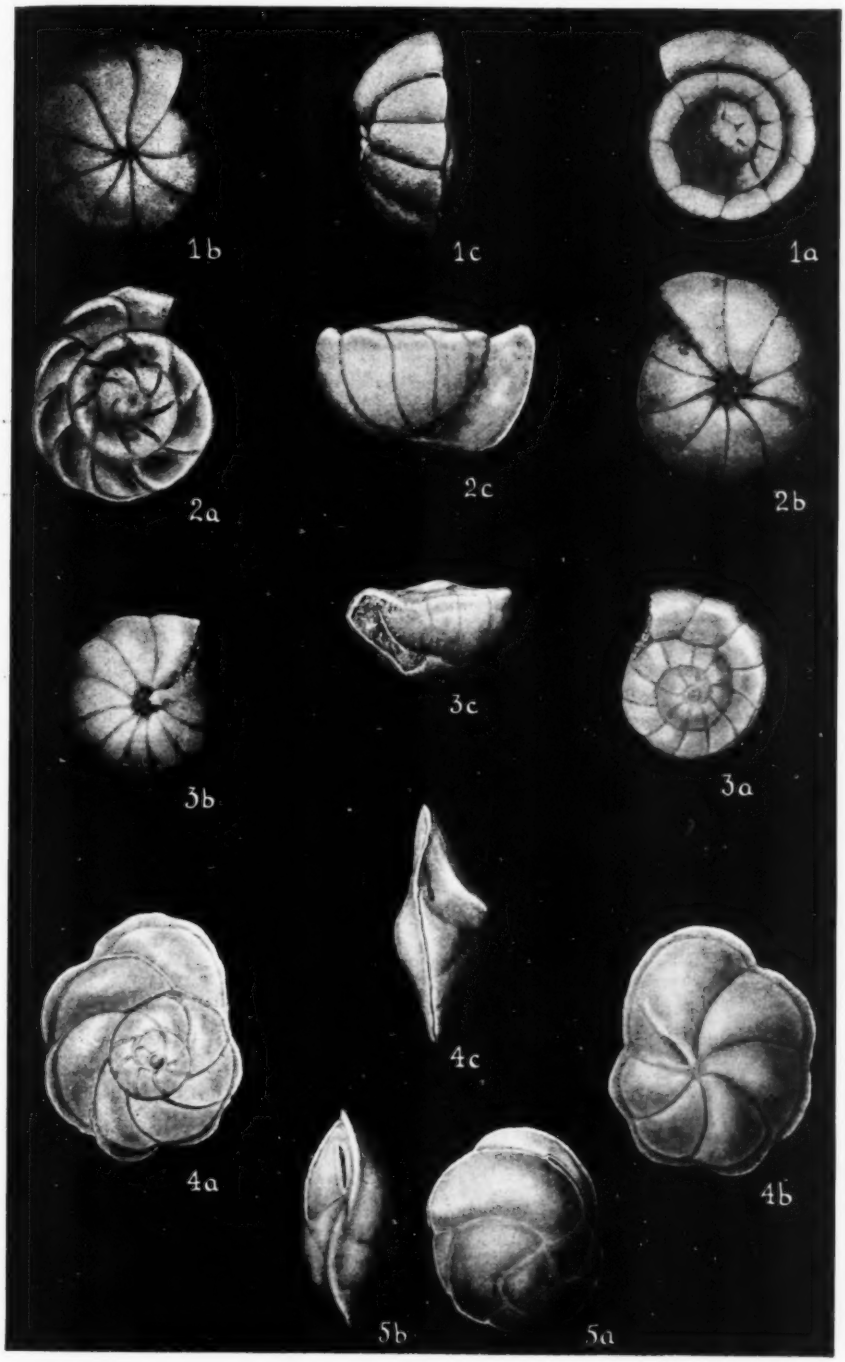
FIGS. 1 *a–c.*—*Gyroidina soldanii* d'Orbigny. (After d'Orbigny's figures in Vienna Basin Report.) *a*, Dorsal view; *b*, ventral view; *c*, peripheral view.

2 *a–c.*—*Gyroidina soldanii* d'Orbigny, var. *altiformis* R. E. and K. C. Stewart, n. var. ×40. *a*, Dorsal view; *b*, ventral view; *c*, peripheral view.

3 *a–c.*—*Gyroidina soldanii* d'Orbigny, var. *rotundimargo* R. E. and K. C. Stewart, n. var. ×60. *a*, Dorsal view; *b*, ventral view; *c*, peripheral view.

4 *a–c.*—*Pulvinulinella smithi* R. E. and K. C. Stewart, n. sp. ×85. *a*, Dorsal view; *b*, ventral view; *c*, peripheral view.

5 *a, b.*—*Cassidulina cushmani* R. E. and K. C. Stewart, n. sp. ×100. *a*, Side view; *b*, peripheral view.


1b
1c
1a
2a
2c
2b
3c
3b
3a
4c
4a
4b
5b
5a

EPONIDES HEALDI R. E. and K. C. Stewart, n. sp.
Plate 8, figs. 8 *a-c*

Test trochoid, biconvex, periphery much rounded and slightly angled; chambers usually 7 in the last-formed coil, fairly distinct; sutures fairly distinct in the last-formed whorl, usually nearly flush with the surface, occasionally sufficiently depressed to give the later chambers a slightly lobulated appearance, dorsal sutures oblique to the direction of coiling; wall very finely perforate, secondarily thickened over earlier whorls; aperture a narrow crescent-shaped slit between the periphery and the center of the ventral side. Diameter averaging about 0.40 mm.; height 0.30 mm.

Holotype (Cushman Coll. No. 12541) and paratypes (Stewart Coll. No. 515) from the Lower Pico at a drilling depth of 4,762 feet in the Miley H. & H. No. 1 well of the Richfield Oil Company of California, Rincon Oil Field, sec. 17, T. 3 N., R. 24 W., Ventura County, California.

The species is named for Mr. K. C. Heald, Staff Geologist of the Gulf Companies, Pittsburgh, Pa., whose classes in petroleum geology inspired our first interest in micropaleontology and our first realization of the possibilities of its practical application.

This species is a peculiarly compact one, with a rounded periphery and the test secondarily thickened, somewhat obscuring the sutures of the earlier coils.

PULVINULINELLA SMITHI R. E. and K. C. Stewart, n. sp.
Plate 9, figs. 4 *a-c*

Test trochoid, plano-convex, dorsal side flattened, ventral side moderately convex; periphery acute with a thin keel about ⅓ as wide as the last-formed whorl of chambers, lobulated; chambers distinct, slightly inflated on the ventral side, five or six in the last-formed coil; sutures distinct, limbate on the dorsal side, curved on both dorsal and ventral sides, dorsal sutures oblique to the direction of coiling, nearly flush with the surface on the dorsal side, somewhat depressed on the ventral side; wall finely perforate, shiny; aperture elongate, narrow, nearly parallel to the periphery, ventral. Diameter up to 0.45 mm.; thickness, 0.18 mm.

Holotype (Cushman Coll. No. 12545) and paratypes (Stewart Coll. No. 516) from the Upper Pico of the mud pits at the Dent Mud Plant about 1½ miles north of Ventura and ½ mile east of Ventura Avenue at the head of Franklin Lane, Ventura County, California.

The species is named for Professor James Perrin Smith of Leland

Stanford Jr. University in appreciation of the kind interest and assistance which he has accorded us in our work.

It seems nearest to *P. pacifica* Cushman but has a lesser maximum thickness between the dorsal and ventral faces and a more definite keel. It is also similar in many respects to *P. culter* (Parker and Jones), but differs from that species in width of keel and number of chambers. Parker and Jones[7] describe and figure the keel of their species as being "as wide as a whorl of the chambers", whereas the keel of *P. smithi* is only about ⅓ that wide. In regard to number of chambers, Parker and Jones show a total of 25 with 9 in the last-formed coil in their illustration of *P. culter*, and describe it as "showing on its upper face about twenty-five (often more) neatly set chambers in a compact spire". Our species has a total of from 15 to 18 chambers with 6 usually making up the last-formed coil.

CASSIDULINA CUSHMANI R. E. and K. C. Stewart, n. sp.
Plate 9, figs. 5 *a*, *b*

Test much compressed, subcircular in side view, the last-formed chamber usually projecting; periphery acute, sometimes slightly lobulate, carinate in fully matured but not in young specimens; chambers distinct, curved, somewhat inflated, four pairs making up the last-formed coil, the chambers of the opposite series showing for about ⅓ of the distance from the periphery to the axis of coiling; sutures distinct, depressed, not limbate; wall very thin, very finely perforate, smooth and polished; aperture an elongate narrow slit following the curve of the previous chamber, usually with a slight tooth. Diameter, 0.30 mm.; thickness, 0.15 mm.

Holotype (Cushman Coll. No. 12543) and paratypes (Stewart Coll. No. 517) from "Lower Pliocene" shales exposed in a road cut at Rincon Point about 150 yards east of the Ventura County line along the highway from Ventura to Santa Barbara, Ventura County, California.

The species is named in appreciation of the encouragement, assistance and inspiring example of Dr. Joseph A. Cushman, Lecturer in Micropaleontology at Harvard University and Director, Cushman Laboratory for Foraminiferal Research.

It is similar to *C. delicata* Cushman but is distinguished from that species by its sharp periphery, the greater extension of the chambers around the opposite sides of the test, the much more angled sutures and the more umbonate nature of the test.

[7] Parker, W. Kitchen, and Jones, Prof. T. Rupert, On some Foraminifera from the North Atlantic and Arctic Oceans, including Davis Straits and Baffin's Bay. Phil. Trans. Roy. Soc. London, vol. 155, part I, p. 421, pl. XIX, fig. 1, 1865.

PULLENIA SALISBURYI R. E. and K. C. Stewart, n. sp.
Plate 8, figs. 2 *a*, *b*

Test nautiloid, biconvex, compressed; periphery rounded; chambers distinct, slightly inflated, typically six in the last-formed coil; sutures slightly depressed and curved; wall smooth, finely perforate; aperture a long narrow slit at the base of the last septal face, with slight upper lip. Long diameter, 0.35 mm.; short diameter, 0.30 mm.; thickness, 0.18 mm.

Holotype (Cushman Coll. No. 12547) and paratypes (Stewart Coll. No. 518) from the Upper Pico of the mud pits at the Dent Mud Plant about 1½ miles north of Ventura and ½ mile east of Ventura Avenue at the head of Franklin Lane, Ventura County, California.

This species is named for the late Professor Rollin D. Salisbury, Dean of the Ogden Graduate School of Science and Head of the Department of Geology at the University of Chicago during our undergraduate days.

It is very close to *P. compressa* Seguenza from the Pliocene of Italy, but differs from that species in having six instead of five chambers and in being somewhat less broadly rounded at the periphery and somewhat more compressed. It has usually been referred to as *P. quinqueloba* Reuss, but is not the same as that species, being much more compressed and having usually six chambers.

SOME RECENT LITERATURE ON THE WESTERN MESOZOIC

FORAMINIFERA

CUSHMAN, JOSEPH A., 1929. Kyphopyxa, a new genus from the Cretaceous of Texas. Contr. Cushman Lab. Foram. Res., 5, pt. 1, no. 70, 1-4, pl. 1, figs. 1-7.

The genus developed from *Flabellina*, and resembles *Plectofrondicularia* in its developmental stages, but has the apertural chamberlet and the radiate aperture of the Lagenidae. Genoholotype *Frondicularia christneri* Carsey, from the lower Taylor marl in Texas, Arkansas and Florida.

CUSHMAN, JOSEPH A., 1929. Some species of Siphogenerinoides from the Cretaceous of Venezuela. Contr. Cushman Lab. Foram. Res., 5, pt. 3, no. 79, 55-59, pl. 9.

Siphogenerinoides plummeri (Cushman), from the Navarro of Texas, is noted.

CUSHMAN, JOSEPH A., and ALEXANDER, C. I., 1929. Frankeina, a new genus of arenaceous foraminifera. Contr. Cushman Lab. Foram. Res., 5, pt. 3, no. 81, 61-62, pl. 10, figs. 1-2.

An arenaceous form, initially planispiral, later triangular in cross-section. Genoholotype *F. goodlandensis* Cushman and Alexander, from the Goodland (Comanchean Cretaceous) and the Upper Cretaceous, Fort Worth, Texas. Another species from the Taylor marl is described in the next paper.

CUSHMAN, JOSEPH A., and WATERS, JAMES A., 1929. Some arenaceous foraminifera from the Taylor marl of Texas. Contr. Cushman Lab. Foram. Res., 5, pt. 3, no. 82, 63-66, pl. 10.

Four arenaceous species are described from well samples of the Taylor marl (Upper Cretaceous) in Texas.

WHITE, MAYNARD P., 1929. Some index foraminifera of the Tampico Embayment area of Mexico (part III). Journ. Pal., 3, 30-58, 2 pls., 1 table of ranges.

The concluding part of this paper describes the Textulariidae, Heterohelicidae, Buliminidae, Pleurostomellidae, and Nonionidae, from the San Felipe, Papagallos, Mendez, and Velasco formations of the Upper Cretaceous. A table of range and abundance is included.

CARMAN, KATHARINE, 1929. Some foraminifera from the Niobrara and Benton formations of Wyoming. Journ. Pal., 3, 309-315, 1 pl.

Describes and figures 3 species from the Benton, 3 from the Niobrara, and 2 common to both groups, mostly from localities east of Centennial, Wyoming. The writer found the Benton and Niobrara very poor in foraminifera.

VAUGHAN, THOMAS WAYLAND, 1929. Actinosiphon semmesi, a new genus and species of orbitoidal foraminifera, and Pseudorbitoides trechmanni H. Douvillé. Journ. Pal., 3, 163-169, 1 pl.

Actinosiphon lacks the radial markings of *Pseudorbitoides*, and also differs by its single layer of equatorial chambers and the stoloniferous passages through the walls of the chambers belonging to the same radial series. It was found in probable Chicontepec (Eocene) in the Aguila, El Cristo No. 1 well, Tantoyuca canton, Veracruz, Mexico, at 3785-3790 feet. *Pseudorbitoides trechmanni*, a high Upper Cretaceous species from Green Island, Jamaica, is redescribed from material picked off a specimen of *Barrettia* by Dr. Trechmann.

VAUGHAN, THOMAS WAYLAND, 1929. Species of Orbitocyclina, a genus of American orbitoid foraminifera from the Upper Cretaceous of Mexico and Louisiana. Journ. Pal., 3, 170-175, 1 pl. Cf: Vaughan, 1929, Proc. Nat. Acad. Sci., vol. 15.

The common orbitoid in the Cárdenas beds (*Exogyra costata* zone, Campanian) at Cárdenas, San Luis Potosí, described as *Lepidorbitoides minima* by H. Douvillé and as a *Polylepidina* by Galloway, is the genoholotype of *Orbitocyclina;* it lacks the cribriform perforations of the equatorial chambers of *Lepidorbitoides*, and differs from *Polylepidina* in the embryonic chambers. A second species, *O. nortoni*, is described from the Upper Cretaceous from a well in Morehouse Parish, Louisiana.

CHURCH, C. C., 1929. The occurrence of Kyphopyxa in California. Journ. Pal., 3, no. 4, p. 411.

This genus described by Cushman as reviewed above, is recorded from the Upper Cretaceous in Kings and Santa Barbara counties, California. "The form appears to be nearly the same as the Texas species, but with some workers it might be considered as new."

OSTRACODA

ALEXANDER, CHARLES IVAN, 1929. Ostracoda of the Cretaceous of north Texas. Univ. Texas Bull. 2907, 137 pp., 10 pls.

Describes 92 species of Ostracoda, most of them new, from the Goodland to Navarro formations inclusive (Comanchean and Upper Cretaceous). The offset plates are clear. A table of range and abundance and a bibliography are given. Some conclusions are: the older "species" require splitting; as split, ostracoda are good index fossils; associations of species are valuable for identification of horizon; zones of abundance are usable; regional variations assist in making local zonations; ostracods permit long-range correlation, as from Texas to Alabama and Maryland; suggestions regarding trans-Atlantic correlation are made; the Kiamichi is of Fredericksburg age, on the evidence of both ostracoda and foraminifera.

ISRAELSKY, MERLE C., 1929. Upper Cretaceous Ostracoda of Arkansas. Ark. Geol. Surv., Bull. 2, 1-28, 4 pls.

Describes 3 species of *Cytherura*, 6 *Cytheropteron*, 1 *Loxoconcha*, 1 *Cythere*, 2 *Cytheridea?*, and 13 *Cythereis*, all new, from the Upper Cretaceous formations, Tokio to Arkadelphia inclusive, in southern Arkansas, with table of range and abundance. The Woodbine and Eagle Ford are stated to be absent in Arkansas,

the Tokio represents the Austin, the *Exogyra ponderosa* zone includes Brownstown, Ozan, Annona and Marlbrook, and the *Exogyra costata* zone includes the Saratoga, the Nacatoch and the Arkadelphia. In some specific names, the author fails to observe agreement of gender with the generic name.

PELECYPODA

HERTLEIN, LEO GEORGE, 1929. Three new specific names for West American fossil mollusca. Journ. Pal., 3, 295-297.

Cucullaea ponderosa Whiteaves, 1900, from the Canadian Cretaceous is renamed *C. grossaforma*, the former name being preoccupied by a Recent New Zealand species of Hutton 1873. Two Oligocene and Pliocene species are renamed.

REESIDE, JOHN B., JR., 1929. Exogyra olisiponensis Sharpe and Exogyra costata Say in the Cretaceous of the Western Interior. U. S. Geol Surv., Prof. Paper 154-I, 267-278, pls. 65-69.

This well documented study records and describes *E. olisiponensis* of the typical and three other varieties, one of them new, for the first time from the United States, in the Lower Mancos with *Gryphaea newberryi* (Lower Turonian). *E. costata* is recorded for the first time from the Western Interior.

STEPHENSON, LLOYD W., 1929. Two new mollusks of the genera Ostrea and Exogyra from the Austin chalk, Texas. Proc. U. S. Nat. Mus., 76, art. 18, pp. 1-6, pls. 1-3.

Describes two oysters from the upper part of the Austin chalk, *Ostrea centerensis*, n. sp., holotype from near Sparks, Bell County; and a species showing original color bands on the shell, *Exogyra tigrina*, n. sp., a Chalk marker which has been locally recognized for some years, type locality near Sprinkle, Travis County. It might be noted that certain Grypheas from the Kiamichi at Fort Stockton show very striking color bands.

RUSSELL, R. D., 1929. Fossil pearls from the Chico formation of Shasta County, California. Am. Journ. Sci., (5), XVIII, 416-428, 12 figs.

Ten loose pearls from the Chico (Upper Cretaceous) near Redding are described and their microscopic structure studied. The Stanford pearl from a *Venericardia clarki* (Cowlitz Eocene, Washington) is described. The *Exogyra texana* pearls from the Fredericksburg of Texas, a London clay (Eocene) pearl from the Isle of Wight, and R. Bullen Newton's excellent summary of all occurrences to 1908, mainly from inocerami, are quoted by the author. He overlooked the summary of German fossil pearls in Klinghardt's "Die Rudisten".

VANDERPOOL, H. C., 1929. A correction of name. Journ. Pal., 3, p. 102.

The Trinity Comanchean species previously recorded as *Ostrea subspatulata* Forbes is *O. camelina* Cragin.

WORTHINGTON, ELIZABETH, 1929. Fossils as horizon markers. Petr. Reporter, I, no. 7, p. 18, San Antonio.

Mention of a few large index fossils of the Edwards, Georgetown, Del Rio, Buda, Eagle Ford, Austin, Taylor, and Navarro formations of the Texas Cretaceous; sketch of *Exogyra ponderosa, Alectryonia lugubris, Exogyra arietina,* and *Inoceramus crippsi.*

AMMONITES

ADKINS, W. S., 1929. Some Upper Cretaceous Taylor ammonites from Texas. Univ. Texas Bull. 2901-I, 203-211, pls. V-VI.

Describes 8 ammonite species, all but one new, and a new brachiopod, from the Taylor in Navarro and Presidio counties. Some significant zonal ammonites from the ever increasing Taylor fauna are found in the beds of phosphatized fossils here described.

BURCKHARDT, CARLOS, 1927. Cefalópodos del Jurásico medio de Oaxaca y Guerrero. Inst. Geol. México, Bol. 47, 106 pp., 34 pls., tabular fossil list.

Describes 64 species and varieties, several new, of ammonites from the middle Bajocian of Duashnu, Mixtepec and the classic locality of Tlaxiaco, all in Oaxaca; upper Bajocian in Oaxaca; upper Bathonian, and lower, middle, and upper Callovian in Guerrero. The fauna is rich in species of *Phylloceras*, *Stephanoceras*, *Reineckia* and *Peltoceras*. Zonal species are indicated. There are slight, but still debatable, relations between the Mexican and the Russian-boreal Jurassic. The half-tone plates are clear.

COLLIGNON, MAURICE, 1929. Les céphalopodes du cénomanien pyriteux de Diégo-Suarez. Ann. Paléont., XVII (1928)-XVIII (1929), 56 pp., 7 pls.

This fauna of pyritic micromorphic ammonites from Madagascar is of great interest in relation to the similar faunas of the Pawpaw, Grayson and Del Rio formations of Texas, assigned by Böse to the basal Cenomanian. Noteworthy resemblances to Texan genera and species, cited by the author, include a new species of pseudocarinate *Flickia*, a genus hitherto reported only from the Vraconnian of Tunis and the Pawpaw of Texas; *Cottreauites*, a new subgenus of *Acanthoceras*, genotype *A. subvicinale* B. L. & T., to which some Texan species referred to *Mantelliceras* and *Submantelliceras* (genotypye: *A. aumalense* Coquand) are referable; numerous phylogerontic ammonites usual in the Cenomanian; some phyllocerids, lytocerids, desmocerids, and belemnites; and a smooth species with simplified sutures, which on account of its shape the author and others persist in referring to *Macroscaphites*. The fauna is sharply Cenomanian, *Pervinquieria* is lacking, and the author keeps clear of the confusion between Albian and Cenomanian prevalent in much of the African literature. These micromorphs have obvious relations with those of Algeria, Tunis and Texas; the relations with India are less evident; and correlation with Spath's detailed zones is not attempted. The plates are excellent.

HANSEN, GEORGE H., 1929. Vertical range of the more common species of the Upper Cretaceous in the Western Interior. Journ. Pal., 3, p. 86.

Compiled ranges of 11 inocerami, 5 oysters, 11 baculites, and 22 other ammonites, from the Turonian (Graneros, Greenhorn, Carlile), the Coniacian-Niobrara, the Santonian-Telegraph Creek, the Campanian-Eagle, and the Maestrichtian (Upper Pierre, Fox Hills).

ECHINOIDEA

LAMBERT, J., 1927. Revision des échinides fossiles de la Catalogne. Mem. Mus. Ciencias Nat. Barcelona, vol. 1, No. 1, 102 pp., 4 pls.

Annotated catalog of Catalonian Triassic, Jurassic, Cretaceous and Tertiary echinoids; many of the Cretaceous, especially Aptian, species have a comparative value for the study of Texan species.

REPTILLA

GOULD, CHARLES N., 1929. Comanchean reptiles from Kansas, Oklahoma and Texas. Bull. Geol. Soc. Amer., 40, 457-462.

Summary of Texan records of dinosaur bones, from Parker, Comanche, Hamilton and Hood counties; Cragin's and Gould's Kansas records; a morosaurian coracoid from upper Trinity beds near Atoka, Oklahoma; and a recently discovered group of tracks from the Glen Rose limestone 35 miles northwest of Uvalde, Kinney County, Texas. Dr. Richard S. Lull identified the tracks as possibly of one of the Camptosauridae, perhaps *C. dispar* or *C. amplus*. Two other reported Glen Rose localities in Texas are recorded.

COASTAL PLAIN

STEPHENSON, LLOYD W., 1928. Structural features of the Atlantic and Gulf Coastal Plain. Bull. Geol. Soc. Amer., 39, 887-900.

From New England to Austin, Texas, the inner edge of the Coastal Plain is defined as being the basal contact of the Cretaceous; from Austin to the Rio Grande, as the Balcones Fault; in Mexico at the limit of pronounced upfaulting or upfolding of Cretaceous strata in the mountain ranges. The paper summarizes the broad seaward tilting, the transverse warping, folding, minor faulting, and salt domes, within the Coastal Plain.

ARKANSAS

BRANNER, GEORGE C., 1929. Geology of America's diamond fields. Pan-Amer. Geol., LI, no. 5, 389-353, 1 map.

The 80 known acres of diamond-bearing peridotite in Pike County, Arkansas, is described. Upon the steeply tilted Paleozoics lie the nearly horizontal Trinity, varicolored shales, clays and sands, and unconformably above these the Tokio sand. The peridotite was intruded through this Cretaceous section. The area was later covered by post-Tertic debris and by Quaternic and Recent sediments. Statistics of exploitation and production are given.

ISRAELSKY, MERLE C., 1929. Correlation of the Brownstown (restricted) formation of Arkansas. Bull. Amer. Assoc. Petr. Geol., 13, 683-684.

On the basis of microfossils, the author believes that the Brownstown (restricted) is to be correlated with the Bonham clay of northeastern Texas and with the type Austin chalk of central Texas; and that the microfossils of the Tokio, mainly arenaceous foraminifera, are different from the Bonham clay fauna.

STEPHENSON, LLOYD W., 1929. Age of Brownstown marl of Arkansas. Bull. Amer. Assoc. Petr. Geol., 13, 1073-1074.

In refutation of Israelsky's microfaunal identification of the Brownstown in Arkansas with the Bonham clay in northeastern Texas, Stephenson records an Austin chalk fauna in the Bonham in Lamar and Red River counties, Texas, and Taylor fossils, notably *Scaphites hippocrepis* in the Brownstown in Sevier County, Arkansas. From the Tokio Stephenson cites fossils which may be post-Eagle Ford but none of which is known in beds of undoubted Eagle Ford age. He suggests that the Bonham and the Blossom together represent the Tokio.

DANE, CARLE H., 1929. Upper Cretaceous formations of southwestern Arkansas. Ark. Geol. Surv., Bull. 1, 215 pp., 29 pls., 4 figs., 1 geologic map.

This excellent and detailed report, in effect a regional Cretaceous manual, cannot be reviewed briefly. The fossils were mostly identified by Dr. Stephenson. Goodland and Kiamichi, the easternmost rocks of the Fredericksburg or Washita divisions, are mapped at Cerrogordo, on the Arkansas-Oklahoma line. Eastwards the Woodbine directly overlies the Trinity sand (identified by *Ostrea franklini, Glauconia branneri,* and *Eriphyla? pikensis*).

Veatch's Bingen formation is divided into Woodbine and Tokio. Veatch's Brownstown marl is divided into a lower part, Brownstown restricted, and an upper part, Ozan. Marlbrook is restricted to the lower marl, and the upper part, Saratoga chalk member, elevated to formational rank. The Nacatoch has a persistent threefold lithologic division. The Arkadelphia is the uppermost Cretaceous in the area and corresponds to upper Navarro. The top of the Kiamichi and of each higher Cretaceous formation except the Ozan and the Annona, is marked by an unconformity. Numerous excellent plates of index fossils are included.

MISER, HUGH D., and PURDUE, A. H., 1929. Geology of the De Queen and Caddo Gap quadrangles, Arkansas. U. S. Geol. Surv., Bull. 808, 195 pp., 18 pls., 9 figs., table of Paleozoic formations.

Areal, historical and economic geology of a region in southwestern Arkansas, which includes Cambrian, Ordovician, Silurian, Devonian, Mississippian, Pennsylvanian, Trinity Comanchean, Upper Cretaceous, Quaternary, and igneous rocks. The area includes the diamond-bearing peridotite district.

ROSS, CLARENCE S., MISER, HUGH D., and STEPHENSON, LLOYD W., 1929. Waterlaid volcanic rocks of early Upper Cretaceous age in southwestern Arkansas, southeastern Oklahoma and northeastern Texas. U. S. Geol. Surv., Prof. Paper 154-F, 175-202, pls. 18-27, figs. 16-18, with geologic map.

The buried volcanoes in the Coastal Plain, in Pike County, Arkansas, are known from their craters, the decomposed filling of their necks, which is almost identical with that of the Kimberley diamond fields, and by their ejecta, ash, sand, lapilli, distributed in the Woodbine and the Tokio, and in Texas also in the higher formations of the Upper Cretaceous. Descriptions and analyses of types of igneous rock, their normic classification, their age; references and descriptions of bentonite and tuffs; summary of volcanic activity in the Coastal Plain during the Cretaceous.

LOUISIANA

CRIDER, A. F., 1929. Pine Island deep sands, Caddo Parish, Louisiana. Struct. Typ. Amer. Oil Fields, II, 168-182, 5 figs.

In the Pine Island field there is 1,600 feet of Upper Cretaceous, Tokio to Arkadelphia inclusive. The Washita red sand, shale, gumbo and other materials surrounding Pine Island, and the Fredericksburg strata, are here removed by erosion, and the Upper Cretaceous is underlain by upper Glen Rose with a porous, oil-bearing zone at its top. The Glen Rose consists of upper limestone, 200 feet; anhydrite zone, 450 feet; lower Glen Rose limestone, 900 feet; and red shale and sand zone, 2,000 feet. The various oil horizons are discussed.

FLETCHER, CORBIN D., 1929. Structure of Caddo field, Caddo Parish, Louisiana. Struct. Typ. Amer. Oil Fields, II, 183-195, 3 figs.

The Upper Cretaceous, Tokio to Arkadelphia, 1405-1575 feet thick, overlies with a pronounced angular unconformity the much folded and beveled Lower Cretaceous beds. Part of the "Woodbine" is of Tokio age, and part, including the tuff and laterite represents reworked débris on the old erosion surface. In addition, part of the "Woodbine" is of Washita age. The strongly folded Comanchean rocks include 1,600+ feet of Washita and Fredericksburg limestones, red shales and sands; Trinity division, composed of 1,650 feet of Glen Rose, a middle red series 2,000 feet thick, and a lower marine series 175+ feet thick.

SPOONER, W. C., 1929. Homer oil field, Claiborne Parish, Louisiana. Struct. Typ. Amer. Oil Fields, II, 196-228, 11 figs.

The Upper Cretaceous, 1570-1625 feet thick, is essentially as reviewed above; the highly folded Lower Cretaceous was beveled off and the Washita and Fredericksburg removed, so that the Upper Cretaceous is directly and unconformably underlain by Trinity, consisting of Upper Glen Rose, 850 feet, red and brown clay and shale, some limestone; a zone of anyhdrite interbedded with limestone, 500 feet thick; lower Glen Rose shale, gray black, some red and brown, clayey limestone, and sandstone, 900+ feet thick; and a basal zone of red and brown shale and clay, with white, gray, and red sand and sandstone.

OKLAHOMA

REDFIELD, JOHN S., 1929. Subdivision of the Bokchito formation in Love County, Oklahoma. Proc. Okla. Acad. Sci., IX, in: Univ. Okla. Bull. (n.s.) no. 456, pp. 76-77.

Bokchito, an arbitrary group name for combined Denton, Weno and Pawpaw formations of the Washita division of the Lower Cretaceous, is 140 feet thick in this area. A detailed section 120 feet thick, consists of 70 feet of Denton overlain by 39⅓ feet of Weno plus Quarry limestone at its top. Some pelecypods and gastropods, but no ammonites, are recorded.

BULLARD, FRED M., 1928. Lower Cretaceous of western Oklahoma. Okla. Geol. Survey Bull. 47, 116 pp., 11 pls., 7 figs.

This excellent and comprehensive paper summarizes the whole subject of the scattered and interesting Cretaceous outliers of the Texas panhandle, western Oklahoma, and the Tucumcari and southern Kansas regions made classic by the

works of Hill, Vaughan, Cragin, Cummins, Gould and others; and describes localities not previously cited in the literature. The literature references are quite extensive. The age of the highest Washita fauna in these outliers hinges on the zone fossils, some of which may have been erroneously identified by earlier authors. The zones of *Hamites* and of *Desmoceras brazoense* of the basal Duck Creek are present; other ammonites roughly called *Ammonites leonensis* do not with certainty indicate higher levels. It is noteworthy that *Oxytropidoceras* maintains the same zonal relations as in Texas and Mexico. The Double Mountain section is essentially like that given by Dumble and Cummins in the "American Geologist".

CENTRAL TEXAS

HILL, ROBERT T., 1929. Trinity of Texas. Bull. Amer. Assoc. Petr. Geol., 13, 519-523.

Historical summary of the use of the term "Trinity" as applied to the basal division of the Texas Comanchean, and citation of publications in which Hill established its priority.

JONES, RICHARD A., 1929. The Paleozoic of the Pedernales Valley in Gillespie and Blanco Counties, Texas. Univ. Texas Bull. 2901-D, pp. 95-130.

This area south of the Central Mineral Region contains igneous, Pre-Cambrian, Cambrian, Cambro-Ordovician, Pennsylvanian, and Comanchean rocks. The basal formations of the Trinity division of the Comanchean (Travis Peak, Gillespie sand, Glen Rose) are briefly described.

COOPER, HERSHEL H., 1929. Producing horizons in southwest Texas. Petr. Reporter, I, no. 7, pp. 5, 30, San Antonio.

Notes many of the oil producing horizons in southern Texas, including the Glen Rose, Edwards, Austin chalk, serpentine at Austin-Taylor levels, Taylor, and Navarro-Escondido, with a tabulation of the fields in horizons in this area from the basal Cretaceous to the Pliocene.

CUYLER, ROBERT H., 1929. Georgetown formation of central Texas and its northern Texas equivalents. Bull. Amer. Assoc. Petr. Geol., 13, 1291-1299. Cf.: same title, Amer. Assoc. Petr. Geol., program 14th annual meeting, Fort Worth, March 23, 1929.

This paper, a condensed summary of a thesis, with detailed sections and literature references omitted, reviews the correlation of the Georgetown formation, 80 feet thick at Austin, with the six equivalent formations, maximum 375 feet, in Grayson, Cooke, Denton, Tarrant, Johnson, and McLennan Counties, Texas. Essentially the present correlation was published by R. T. Hill in 1902 and figures in many subsequent papers; the author's figure 2 is with the addition of the zone of *Pervinquieria wintoni*, practically identical with Hill's figure 29, page 245. The author's assignment of the Kiamichi clay to the Fredericksburg division was made by Taff in 1892, and has been discussed by at least seven later writers. No evidence is cited to support the alleged occurrence of Kiamichi at Austin. *Pervinquieria trinodosa* Böse is stated to be a typical Duck Creek fossil; *Kingena wacoensis* and *Exogyra arietina* are stated to be index fossils of the Georgetown and Del Rio respectively. The Pawpaw is erroneously portrayed as

consisting of sand with limestone seams from Denton to McLennan County, and as persisting to the Brazos; the Main Street in McLennan County is portrayed as the partial equivalent of the Del Rio in Travis County; some recent formation thicknesses from core drillings are not included.

SELLARDS, E. H., 1929. Mineral resources of Texas: Bastrop County. Bureau of Economic Geology (preprint), Austin, 24 pp.

Data on stratigraphic column, thicknesses of formations, structural geology, clay, glauconite, iron, sand and gravel, water, lignite, oil and gas, ochre; data on Yost oil field to July 1, 1929; summary and interpretation of records of 36 wells; logs of Freytag-Valenta, Linoa Garza 1, and English 3.

ADKINS, W. S., 1929. Mineral resources of Texas: Bell County. Bureau of Economic Geology (preprint), Austin, 10 pp.

A preliminary report, giving table of thickness of Cretaceous formations, and notes on faults, clay, limestone, water, and some wells.

JUDSON, SIDNEY A., 1929. Résumé of discoveries and developments in northeastern Texas in 1928. Bull. Amer. Assoc. Petr. Geol., 13, 611-616.

Records Woodbine in the Boggy Creek salt dome, Anderson-Cherokee Counties; Austin chalk and Georgetown in the Bullard dome, Smith County; Navarro to Georgetown in the Keechi dome, Anderson County; Washita sandstone in Shelby County, top of Cretaceous to Glen Rose in Rusk County, Texas Company's Goodwin No. 1; Pecan Gap to Bingen in Smith County; Austin chalk and Woodbine in Cherokee County.

MORRISON, T. E., 1929. First authentic Cretaceous formation found on Gulf Coast salt domes of Texas. Bull. Amer. Assoc. Petr. Geol., 13, 1065-1069.

In the 1,000 wells drilled in the Gulf Coast salt dome area, Upper Eocene sediments were the oldest reached. A well on the South Liberty salt dome recovered a 35-foot core of foraminiferal Upper Cretaceous marl included in the body of the cap rock. Forty species of Cretaceous foraminifera are listed from this material. The significance of the primary nature of the cap rock, and the Cretaceous source of the salt, are discussed.

STEPHENSON, LLOYD W., 1929. Unconformities in the Upper Cretaceous series of Texas. Bull. Amer. Assoc. Petr. Geol., 13, 1323-1334.

A summary of sedimentary breaks in the Texan Upper Cretaceous, and a list of criteria for such breaks. These breaks separate most of the Upper Cretaceous formations at the outcrop. An unconformity at the Grayson-Woodbine contact (base of Upper Cretaceous), with all but 2 feet of the Woodbine removed, is described from near Cedar Mills, Grayson County. An unconformity at the Woodbine-Eagle Ford contact from Tarrant County southwards is described from localities in Johnson and Hill Counties. An unconformity within the Eagle Ford is suggested as partial explanation of the strong southward thinning of the Eagle Ford; this break was seen near Waco and, at a level two feet below the top of the formation, near Austin. The Eagle Ford-Austin chalk unconformity is widespread, and extends at least from northeastern Texas to Hays County. The Austin-Taylor unconformity is most pronounced in McLennan County, where 250 feet of upper Austin chalk stated to be present in Travis and Dallas Counties

has been removed. The Pecan Gap chalk has unconformities above and below, in Hunt and Collins counties. At Austin and southwards the basal Navarro (*Exogyra cancellata* zone, and Nacatoch) is absent, and the upper Navarro rests upon the Taylor.

WEST TEXAS

ADAMS, JOHN EMERY, 1929. Triassic of West Texas. Bull. Amer. Assoc. Petr. Geol., 13, 1045-1056.

The non-marine upper Triassic red and non-red conglomerate, sandstone, and shales, called Dockum beds in west Texas, are divided into Santa Rosa and Chinle as in the New Mexico Triassic; their lithologic features are described and criteria for recognition of Triassic given.

KROENLEIN, GEORGE A., 1929. Deep test in Terrell County, Texas. Oil and Gas Journ., vol. 28, no. 27 (Nov. 21, 1929), pp. 74, 196, 198.

In the bed of Pecos River near the northwest corner of Val Verde County and on the axis of the northwest-southwest trending Pandale-Stone structure, there is an inlier of Permo-Pennsylvanian bedded gray limestone, dipping apparently southwest, and containing Wolfcamp or Cisco fossils. This is directly overlain by Comanchean limestone, but farther south the basement sand of the Comanchean occurs. Northwest of this inlier the Transcontinental's Goode No. 1 is being drilled near the axis of the structure.

WILSON, JOSEPH M., 1929. Concho Bluffs of Crane, Ector and Winkler Counties, Texas. Bull. Amer. Assoc. Petr. Geol., 13, 1069-1071.

This well-known west-facing escarpment, forming the western edge of the Staked Plains in this region, contains the following Comanchean section unconformably overlying the Triassic: basal Cretaceous sand, called "Trinity"; Walnut clay, 3 feet; Edwards, 62-90 feet, yellow sandy limestone at base, gray and alternately hard and soft limestone above. The Cretaceous beds reflect Permian structure, and the escarpment parallels the east side of the Permian fold. A combination surface and subsurface structure map is given.

ROBERTS, H. N., 1929. Some underground waters of West Texas and their geological horizons. Proc. 11th Texas Water Works Short School, Austin, pp. 82-90.

This paper describes water horizons in the Permian, Triassic, Comanchean and later Cenozoic beds in West Texas. The Comanchean (pp. 86-89) water-bearing beds are described with special reference to the Howard County column. It is stated that the three formations of the Trinity, namely Travis Peak, Paluxy and Glen Rose, here lose their identity, and are collectively referred to as Trinity, 70-80 feet thick. The Trinity sea had two large embayments, joining near Gillespie County, and the western one of these covered parts of Crane, Upton and Pecos Counties. The Trinity sea was transgressive, and its sediments less mineralized than in a regressive sea. The upper portion of the Trinity sand in Howard County has rounded, fine (av. diam. 0.473 mm.) grains with calcareous cement, and is seldom water-bearing. The middle member consists of rounded, coarser (0.481 mm.) grains, and by experiment takes up 37% of its weight of water. It contains water-bearing siliceous gravel lenses composed of coarser fragments

(extremes of diameter 2-30 mm., mainly 5-8 mm.). The available water-bearing portion of the Trinity is estimated at 38 feet in thickness, 15% porosity extractable, and the computed available storage 1,066 million gallons per square mile. Catchment areas and water losses are discussed.

HAWLEY, JOHN B., 1929. An underground water research at Big Spring, Texas. Proc. 11th Texas Water Works Short School, Austin, pp. 91-95.

Describes the Comanchean section, the synclinal and sinkhole features, water analyses, and estimated available artesian resources, in the Big Spring area.

LONSDALE, JOHN T., 1929. An underground placer cinnibar deposit. Econ. Geol., XXIV, 626-631.

On section 38, block G 12, Brewster County, Texas, in the Terlingua quicksilver district, is a narrow, nearly vertical, pipe-shaped solution channel in the Comanchean Edwards limestone, over 400 feet deep, filled with red silt containing grains, cobbles and fragments of cinnibar. At one place a bedding plane in the silt showed mud cracks. This is an underground placer deposit. Some bones from this channel were identified at the Denver Museum as Pleistocene. It might be added that an *Equus* tooth, submitted to Dr. W. D. Matthew, was determined as probably early Pleistocene.

BAKER, CHARLES L., 1928. Desert range tectonics of Trans-Pecos Texas. Pan-Amer. Geol., L, 341-373.

A study of the tectonic history of the Trans-Pecos mountains, and a consideration of the objections to the basin range hypothesis derived from this area. The latest great period of orogeny, with formation of extensive lake beds, is dated about the Loup Fork upper Miocene. The faulting in the Trans-Pecos ranges is thus old enough for the topographic evidence to have become blurred. Extensive details of faulting and other structure are described. There are 8 plates of mountain scarps.

NEW MEXICO-ARIZONA

REESIDE, JOHN B., and BAKER, ARTHUR A., 1929. The Cretaceous section in Black Mesa, northeastern Arizona. Journ. Wash. Acad. Sci., 19, no. 2, 30-37.

A 1,545-foot section at the north end of the mesa is described. It consists of 100 feet of Dakota, 610 feet of beds previously referred to the Mancos, and 835 feet of beds previously referred to the Mesaverde. No fossils were found in the Dakota. The shale called Mancos is only a portion of the San Juan Basin Mancos, and is Turonian in age. Its lower one-fourth, with *Ostrea soleniscus, Gryphaea newberryi, Exogyra laeviuscula, Inoceramus labiatus* and *Metoicoceras* corresponds to the Graneros and the Greenhorn. A second one-fourth yielded no fossils. The next one-fourth, with *Prionotropis woolgari* corresponds to the lower Carlile. It is conjectured that the top of the Benton is here missing. The basal "Mesaverde" is here Coniacian in age and contains Niobrara fossils. Fossils collected by Reagan and Gregory from the upper "Mesaverde" are of Niobrara age, as *Inoceramus stantoni;* and therefore all the beds here misnamed Mesaverde are likely Niobrara.

DARTON, N. H., 1928. "Red beds" and associated formations in New Mexico. U. S. Geol. Surv., Bull. 794, 356 pp., 62 pls., 173 figs.

This book is essentially a geology of New Mexico, and will serve as an appropriate text to the state geologic map recently issued. After a summary of the geologic formations, the author devotes 283 pages to descriptions of local geology, covering most of the area of the state in representative sections.

WESTERN INTERIOR

RUSSELL, WILLIAM L., 1929. Stratigraphy and structure of the Smoky Hill chalk in western Kansas. Bull. Amer. Assoc. Petr. Geol., 13, 595-604.

This upper Niobrara formation, 600-700 feet thick, is divided into four groups on the basis of bentonite layers of various thicknesses, hard and soft chalk ledges, shales, colors, and erosional peculiarities. The formation is extensively faulted. Structure based on local dips is unreliable. No fossils are listed.

JOHNSON, J. HARLAN, and AURAND, HARRY A., 1929. A preliminary contribution to the Benton paleogeography of eastern Colorado. Bull. Amer. Assoc. Petr. Geol., 13, 850-853.

Contrary to the widespread notion of diastrophic quiescence in the Rocky Mountain region of Colorado during Upper Cretaceous time, the authors record an increased thickness of "Dakota", Benton and Niobrara on the flanks of the Berthould structure, Loveland quadrangle. According to the writers' interpretations, these structures projected up into the "Dakota", Benton and Niobrara seas, and received increased deposition on their western flank. There was little deposition on their crests until the Pierre, which covered them in full thickness. These highs are confirmed by the magnetometer.

RUBEY, WILLIAM W., 1929. Origin of the siliceous Mowry shale of the Black Hills region. U. S. Geol. Surv., Prof. Paper 154-D, pp. 153-170.

This basal Benton (lower Graneros) shale, known from Wyoming, Montana, western South Dakota, and northern Colorado, contains much silica, derived from the alteration of volcanic ash, probably by original decomposition by long exposure to sea water and later precipitation by decaying organic matter.

DOBBIN, C. E., and REESIDE, JOHN B., JR., 1929. The contact of the Fox Hills and Lance formations. U. S. Geol. Surv., Prof. Paper 158-B, pp. 9-25.

Each supposed discordance between the Lance and the Fox Hills in this area is caused by some other phenomenon, such as small local faulting or cross-bedding.

EASTERN MEXICO

MÜLLERRIED, FEDERICO K. G., 1929. Geología petrolera de las zonas sur del estado de Tamaulipas y norte del estado de Vera Cruz. Inst. Geol. México, Anales, 3, 55-68.

This region, at the west edge of the Gulf Coastal Plain between Tampico and San Luis Potosi, contains Victoria (=Tamaulipas) cherty, non-rudistid limestone, stated to be younger than the El Abra foraminiferal limestone. The San Felipe limestone, 250 meters thick, follows; fossils hitherto cited from it are

listed. For the Papagallos shale, 400 meters thick, the published megalofossils are listed. Tertiary formations in the area: Chicontepec, Alazan, Meson, San Rafael. The usual correlations with Texas and Europe are tabulated. However, the Austin chalk is correlated with the entire San Felipe, and is erroneously referred to the Turonian.

CUMMING, JORGE L., 1928. Informe preliminar acerca del reconocimiento geológico-petrolero de la parte norte del Estado de Coahuila. Inst. Geol. México, Folleto No. 29, 28 pp., 1 table, 1 map.

Brief summary of Cretaceous formations, and discussion of oil possibilities.

LOZANO, ENRIQUE DIAZ, 1929. Algunas palabras acerca de la designación de las formáciones geológicas en la régión petrolera de México. Bol. Petr., XXVII, no. 3, 325-326.

Brief summary of correlations between Cretaceous formations in Texas and the Tampico embayment as given in recent literature; omits mention of important discussions in Böse and Cavins, Univ. Texas Bull. 2748. The Georgetown, referred by the author to the Cenomanian, is generally considered Albian; he unequivocally refers the Velasco to the Navarro-Fox Hills; the formations of the Fredericksburg division are inadvertently listed as being those of the Trinity division.

LOZANO, ENRIQUE DIAZ, 1928. Los microorganismos fosiles y la geología de petróleo. Bol. Petr., XXVI, nos. 4-5, 397-400.

Deals with the use of foraminifera and other micro-fossils in correlating the sedimentary formations of the Tampico embayment, especially in the Cretaceous, with the formations in Texas. The Tamaulipas, El Abra, and Tamasopo limestones are collectively referred to the lower Cretaceous of Texas, although Böse and others have presented field relations and recorded fossils which tend to show that the Tamasopo is a rudistid-reef facies of the lower Senonian, correlatives of the San Felipe or the Austin chalk, and overlain directly at many places by the Cárdenas beds, as near Cárdenas or at Tula, Tamaulipas. The San Felipe is correlated with the Eagle Ford and Austin chalk; the Mendez and Papagayos with the Taylor; and the Velasco with the Navarro, a correlation still open to question. There are brief remarks on the Tertiary section.

HEIM, ARNOLD, 1926. Notes on the Jurassic of Tamazunchale (Sierra Madre Oriental, Mexico). Eclogae Geologicae Helvetiae, XX, no. 1, 84-88.

The steeply tilted rocks at the inner edge of the Gulf Coastal Plain, along the Mexican highlands ("Mesa Central"), include upper Jurassic, mainly Kimmeridge, the fossils having been identified by Burckhardt. This is the nearest Jurassic outcrop to the southern oilfields, and in the absence of wells penetrating the entire Cretaceous, has a speculative bearing on what underlies the Cretaceous, on the source of the oil in the Golden Lane, and on the possibility of its revival by deeper drilling.

HISAZUMI, HISAKICHI, 1929. Informe preliminar acerca de la geologia petrolera de la zona comprendida entre los rios de Tuxpan y Misantla, en los estados de Puebla y Veracruz. Inst. Geol. México, Anales, 3, 1-54.

This traverse extends from the edge of the Mexican highlands near Necaxa northeast of Mexico City, eastwards across the Coastal Plain along the Tuxpan

River to the Gulf of Mexico, near the southern end of the "Golden Lane". The edge of the highlands is a very complicated region of igneous, metamorphic and sedimentary rocks, of highly involved structure and succession. The pre-Jurassic rocks are mica-schists, quartzites, conglomerates, and sandstones or arkoses. The well known Liassic zone, a strip marked by tile roofs and hydroelectric light in the villages, consists mainly of black, some varicolored slates, with *Aspidoceras, Aucella, Arietites* and other fossils. Beds of black slate containing pyrite concretions and *Perisphinctes plicatiloides* are conjectured to be middle Jurassic (?) or Oxfordian. The upper Jurassic black limestones are divided into 3 zones: (a) Nerinea, (b) Rhynchonella, and (c) Idoceras. The Huayacocotla section, investigated by Burckhardt but still unpublished, is in the same general succession of rocks. The lower Cretaceous is classified as (a) Necoxtla slates, (b) Maltrata limestone, Hauterivian to Aptian, and (c) Escamela limestone, probably Albian-Cenomanian. The Coastal Plain begins with the Upper Cretaceous: San Felipe limestone, and Papagallos shales. The Eocene (Chicontepec, higher beds), the Oligocene (Alazan, Meson), and the Miocene (Tuxpan) are briefly discussed. Photographs of oil seeps.

WESTERN MEXICO

SANTILLAN, MANUEL, 1929. Geologia minera de las regiones norte, noroeste y central del Estado de Guerrero. Inst. Geol. México, Bol. 48, 45-102, 2 maps, 3 profiles.

The map shows a considerable area of Cretaceous in the region between Coyuca and Iguala, which from the text appears to consist mainly of limestones locally converted to marble, and some marls. Most of the region consists of complicated extrusives and instrusives. Triassic and Jurassic underlie the Cretaceous limetones.

VIVAR, GONZALO, 1929. El Petróleo en Aragon, Guadalupe Hidalgo, D. F. Insti. Geol. México, Anales, 3, 87-92.

The igneous region near Mexico City has been notable for years for artesian mineral water, which in some wells contains a large quantity of carbon dioxide and a small quantity of oil. Analysis shows considerable sodium chloride and calcium bicarbonate, and some lithium and boron. The source of the oil is conjectured to be buried Cretaceous, since Cretaceous limestones outcrop 50 kilometers north of the locality.

HISAZUMI, HISAKICHI, 1929. Informe geológico preliminar de la parte norte del Estado de Sinaloa. Insti. Geol. México, Anales, 3, 95-109.

This is a region of 2,000 meters elevation, with high mountains and deep canyons, overlooking to the west the Pacific Coastal Plain. Cretaceous rocks are overlain by a Tertiary system of extrusive andesites and rhyolites, and there are some granitic instrusions. A 1,000-foot section of Cretaceous black limestones and slates, sandier at the top, revealed no fossils but indeterminate ammonites. Similar rocks at the mining camp Guadalupe de los Reyes have been correlated with the Comanchean limestones and slates described by Böse from Durango.

ANDERSON, F. M., 1928. Late Cretacic fossils from Lower California. Pan-Amer. Geol., L, 283-284, pl. ix.

Records from the Chico (Upper Cretaceous) beds near Santa Catarina, Baja California, some noteworthy ammonites: *Pachydiscus caterinae* Hanna and Anderson, diameter up to 19 inches and weight up to 120 pounds; Nautilus sp., *Hamites ovatoides* H. & A., *Hamites sternbergi* H. & A., all relatively large. The age of the fossils is stated to be Santonian. Comparisons with Indo-Pacific species are made.

KELLER, W. T., 1928. Stratigraphische Beobachtungen in Sonora (Nordwest Mexico). Eclogae geologicae Helvetiae, 21, no. 2, 327-335, 1 map.

Pre-Carboniferous and Carboniferous rocks, similar to those near Bisbee, are described, and the Carboniferous fossils listed. Marine Carnic upper Triassic, discovered in the Altar district, was identified by Dr. C. Burckhardt from the ammonites as belonging to the *Tropites subbullatus* zone. This fauna is compared with those of California and Zacatecas. Fossiliferous Liassic is recorded from near Santa Rosa, Sonora. Lower Cretaceous, compared with that of the Bisbee district, is described. There is a full bibliography.

PALMER, ROBERT H., 1928. The rudistids of southern Mexico. Calif. Acad. Sci. Occasional Papers XIV, 137 pp., 18 pls.

This fine monograph summarizes the rudistid occurrences of the region, and deals with other records from western America. In the systematic portion numerous species, belonging to seven new and thirteen previously described genera of rudistids, caprinids and related forms, are treated. The species are mostly of Cenomanian and Turonian age. A full bibliography is given. The half-tone plates are clear.

PACKARD, EARL, and LUPHER, R. L., 1929. Jurassic and Cretacic Rudistids from Oregon. Am. Pal. Soc. (Palo Alto meeting), Pan-Am. Geol., LII, 155.

A new upper Liassic rudistid from Oregon is taken as the type of a new family. A new genus from the Chico, related to *Coralliochama* C. A. White, is noted. These genera show novel and extreme specializations of the gregarious habit. This constitutes the northernmost American record for the rudistid group.

W. S. ADKINS.

RESEARCHES IN PALEONTOLOGY

Dr. Asa A. L. Matthews of the geological department of Oberlin College has completed his monograph entitled "Lower Triassic Cephalopod Fauna of the Fort Douglas Area, Utah". It has been published by the University of Chicago Press as No. 1 of a new series of Walker Museum Memoirs. The work is a comprehensive publication of 46 pages and 11 plates, in which 67 species are figured and described.

Dr. Hugo Storm of German University, Prag, has published in a recent number of Lotos a paper entitled "Contributions to Knowledge of the Foraminiferal Fauna in the upper Turonian and Emscher of the Bohemian chalk formation.

Dr. Charles Schuchert with G. Arthur Cooper has written a paper on the upper Devonian of Perce, eastern Quebec.

Dr. Carey Croneis of the department of paleontology, University of Chicago, has a paper in press by the Arkansas Geological Survey on the "Geology and Paleontology of Paleozoic Formations of Arkansas". He is describing also some new ammonoids from the Atoka formation.

Dr. C. E. Condra, C. O. Dunbar, and R. C. Moore gave a paper at the meeting of the Geological Society of America at Washington during the holidays on the persistence of thin beds in the Pennsylvanian of the northern Mid-Continent region.

J. Brooks Knight working at Peabody Museum, Yale University, has prepared a paper on Pennsylvanian Zygopleuroid gastropods.

G. Marshall Kay of the geological department, Columbia University, presented a paper before the Paleontological Society at Washington on ostracoda of the lower Mohawkian formation, and a second paper on formations subjacent to the Black River-Trenton line.

Mrs. Mildred Fenton of the Buffalo Museum of Science is making a study of *Aulopora*, a genus of Paleozoic bryozoa.

Carroll Lane Fenton and Mildred A. Fenton of the Buffalo Museum of Science and geological department of the University of Buffalo presented a paper before the Paleontological Society on algal beds in the Belt series of Glacier National Park.

L. W. Ploger, Assistant Professor of Geology, Syracuse University, is studying the faunas and stratigraphy of the Chemung group in western New York preparatory to mapping the geology of the Cattaragus quadrangle.

Gayle Scott of Texas Christian University and F. B. Plummer of the University of Texas are preparing jointly a monograph on the Permo-Carboniferous cephalopods of north-central Texas. They have collected abundant material from ten different zones ranging from the top of the Wichita-Albany group to the base of the Bend group.

W. A. Kelly of the geological department of Michigan State College is engaged in a study of the lower Pennsylvanian faunas of Michigan.

Edward L. Troxell of Trinity College presented a paper before the Paleontological Society on new species from the lower Eocene.

Dr. R. G. S. Hudson, University of Leeds, is engaged in a monographic study of the genus *Lophophyllum*, a Paleozoic coral.

Prof. A. S. Romer and Paul Miller, Associate Curator, have just returned to the University of Chicago from the Karoo Desert, South Africa, where they have spent the past summer and fall in collecting Permian vertebrate fossils. The search for these fossils began in the western part of the Karoo Desert and proceeded eastward along the southern flanks of the Nieuwveldt Mountains and the Sneeubergs. Over seventy boxes of fossil remains have been shipped to Chicago for study and mounting during the coming year.

J. A. Cushman and C. I. Alexander are writing a paper on the foraminiferal faunas of the Fredericksburg group of north Texas.

Leo Hendricks, geological department of Texas Christian University, is making a detailed study of mineral grains in the Wilcox formation of north Texas.

F. N. Anderson has published a paper in the California Academy of Science on the lower Tertiary deposits of Columbia and their molluscan and foraminiferal faunas.

Margaret Fuller Boos has prepared for publication a guide to the geology of Rocky Mountain National Park.

H. N. Coryell of the paleontology department of Columbia University has completed a study of the fossil corals of Porto Rico which will be published by the New York Academy of Sciences.

Lloyd G. Henbest gave a paper at the annual meeting of the Paleontological Society at Washington on selective strains in paleontology.

H. G. Clinton of Manhatten, Nevada, has recently discovered plant fossils in Cambrian rocks of Nevada. In a limestone on the 400 ft. level of the White Caps mine. He collected seven specimens resembling mushrooms in appearance, which have been identified as parts of ferns.

F. B. PLUMMER, *Secretary.*

THE FORT WORTH SECTION

The Fort Worth section of the Society of Economic Paleontologists and Mineralogists have continued active during the fall and winter. W. M. Winton is President and C. I. Alexander, Secretary. At the last meeting which was held December 28 at Texas Christian University I. H. Cram, paleontologist for the Pure Oil Co., Tulsa, delivered a paper on Pre-Pennsylvanian stratigraphy of southern Oklahoma.

MICROPALEONTOLOGICAL BULLETIN

DEPARTMENT OF PALEONTOLOGY, STANFORD UNIVERSITY

During the past three years the Department of Paleontology, Stanford University, has published from time to time issues of their Bulletin of Micropaleontology. F. L. Johnson is editor and M. M. Kornfeld is business manager.

Number 12, just received, contains the following articles:

Discocyclina in Oregon.....by F. E. Turner
Mounting medium.....by E. Wayne Galliher
Heterogamy in foraminifera (abstract from the original paper by J. Hofker, in which he discussed trimorphism: Tijd. Ned. Dierk. Vereen., ser. 2, vol. 19, 1925)
by J. H. McMasters
Form of foraminiferal shells (abstract of Thompson's "Growth and Form").....by Ward Smith
Discussion:
A. On methods of obtaining internal casts of foraminifera.
B. Pyritized diatoms.

This publication is mimeographed in excellent type and is now bound in cover pages. The articles are clearly written and well edited. The short contributions will be of interest to micropaleontologists not only in universities but also in the commercial laboratories where literature is not so easily available and where abstracts of foreign papers should be most welcome. This effort on the part of Stanford University to distribute timely paleontologic information should receive the thanks and support of all the members of the Society.

F. B. PLUMMER, *Secretary.*

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[1] The distinction between full members and associate members is drawn according to membership in the American Association of Petroleum Geologists, the organization with which the Society is affiliated. Among our associated members are paleontologists of highest scientific attainments whom the Society is most pleased to include in its group.